Wm H Brewer
Yale College
1867

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Hygiene,

OR,

HEALTH

AS

DEPENDING UPON THE CONDITIONS

OF

THE ATMOSPHERE,

FOODS AND DRINKS, MOTION AND REST,

SLEEP AND WAKEFULNESS,

SECRETIONS, EXCRETIONS, AND RETENTIONS,

MENTAL EMOTIONS, CLOTHING,

BATHING, &c.

"Health and good estate of body are above all gold."—Eccl. xxx. 15.

BY

JAMES H. PICKFORD, M.D.

MEDICINA LITERIS

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HYGIENE.

PREFACE.

Hygiene has been defined to be that branch of medicine the end and aim of which are to point out the conditions on which health depends, and the means by which that inestimable blessing may be sustained in all its purity and entirety.

Hygiene embraces, therefore, all those matters which, when in a normal condition, and properly used, contribute to make up, to perfect, and to sustain health; but which, on the contrary, when abused, retained, taken in excess, in insufficient quantity, or in a vitiated or corrupt state, lead to disorder or disease.

This division of the healing art, under the name of "NON-NATURALS," received at the hands of the ancient physicians, so far, at least, as their limited knowledge would admit, the greatest attention and consideration.

By the term "*non-naturals*" were understood all those things which are *essential to life*, but which

neither enter into the composition of the animal œconomy, nor form part of the living body.

These comprehend *air, foods and drinks, motion and rest, sleep and wakefulness, secretions, excretions, and retentions, mental emotions, clothing, bathing, &c.*

Non-naturals formed, either in part, or as a whole, the subjects of numerous essays and dissertations. Hippocrates has left us a treatise, Περὶ 'Αέρων, Ὑδάτων, καὶ Τόπων, an example which was followed by Galen, Aëtius, Rhases, Avicenna, Celsus, and others, and, in later times, by Sennertus, Blanchard, &c.

These primitive efforts to attain to a due knowledge and accurate estimate of the beneficence, wisdom, and design in creation, of the adaptation of means to the end, and of those universal, fixed, and immutable laws upon the due observance of which health and life depend, and upon the violation of or departure from which disorder, disease, or death ensues, though worthy of respectful consideration, are frequently obscured by, and inextricably interwoven with, the fanciful speculations, the theoretical opinions, and peculiar dogmas of each period.

The rapid strides, however, which natural philosophy, chemistry, and physiology have made during

TO

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"THE FIRST PRINCIPLES OF MEDICINE,"

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MEMBER OF THE SENATE OF THE UNIVERSITY OF LONDON,

THESE PAGES,

AS A TRIBUTE TO HIS EMINENT TALENT,

PUBLIC CHARACTER, AND PRIVATE WORTH,

ARE INSCRIBED,

BY HIS VERY SINCERE FRIEND,

JAMES H. PICKFORD.

the last quarter of a century in the hands of Faraday, Prout, Humboldt, Owen, and other savans, both of this and other countries, have rendered clear, intelligible, and easy of demonstration, much which before existed but as random guesses and as glimmerings in the dark.

This advance of modern science, and the simultaneous march of civilization, having outstripped alike the writings and the theories of the "old fathers" of physic, a manifest deficiency has arisen in the literature of this branch of medicine, which the author ventures to hope he may, in some measure at least, contribute to supply.

On matters of Hygiene we have in this country no standard authority, no single work, no condensed summary, no manual even, to which to refer. Its immutable and life-giving principles are scattered through piles of volumes, rich in all the mysteries and wonders of creation and of science, but on which, be our resources never so ample, we have often the greatest toil and the utmost difficulty to fasten.

At a time when so deep an interest is evinced in "Sanitary Reform" and "Public Health," it may be useful, both to the professional and general

reader, to have some work of easy reference to which to turn on the great variety of subjects which these matters involve.

It is to endeavour to supply this desideratum that the writer has ventured to embody all that seems to be necessary to be acquired on those various subjects which make up and constitute Hygiene.

The necessity for a treatise on this subject has become more apparent since the examining boards of both branches of the public service, the army and navy, of the East India Company's medical service, of the University of London, and other licensing bodies, have proclaimed their opinions of the importance of a due knowledge of Hygiene, by making it one of the subjects of examination of the candidate for a commission, or for their degree in, or licence to practise medicine.

The author's aim is to present to his professional brethren, to the medical student, and to the public at large, a plain and faithful transcript of accurate research, observation, and experience, a simple and exact statement of facts and of admitted truths, together with such inferences and deductions as the subject may appear to warrant and demand. With

this view he has consulted the best authorities, and has not, he trusts, omitted to acknowledge the sources whence his matter has been derived. Where differences in statements or opinions occur, they are placed in juxta-position, so that the reader may have an opportunity of drawing his own inferences, it may be, of exercising his own experimental knowledge on the subject.

Indocti discant, et ament meminisse periti.

The *First Part* embraces the physics of the atmosphere, the seasons, temperature, rain, winds, and pressure ; the respiration of plants and animals, the circulation of the blood, the chemistry of respiration, and animal heat ; infection, contagion, malaria, sewerage, drainage, ventilation, and climate in connection with disease.

The Second Part will consist of digestion, foods and drinks, their impurities and adulterations.

The Third and last part will include motion and rest, sleep and wakefulness, secretions, excretions, and retentions, mental emotions, clothing, bathing, &c.

Brighton,
May 1, 1858.

Hygiene.

PART I.—ATMOSPHERE.

A I R.

CHAPTER I.

THE ATMOSPHERE.

1. *Earth, form of.*—The planet which we inhabit is an elliptical spheroid of rotation, of which the lesser axis passes through the poles. The measure of oblateness of the polar diameter is $\frac{1}{299}$th. The polar semidiameter is about $2\frac{7}{8}$ geographical miles shorter than the equatorial semidiameter.

2. *Earth, density of.*—The mean density of the earth, according to Reich, is 5·44, or nearly $5\frac{1}{2}$ times greater than pure water.

3. *Earth revolves on its own axis, and travels in its orbit.*—The earth *revolves* on its own axis at the incredible rate at the equator of upwards of 1,000 miles an hour; and *travels* in its orbit at a mean velocity of 68,000 miles in the same space of time. Its *diurnal rotation* is completed in 86,400 seconds = 24 hours.

4. *Earth surrounded by an atmosphere.*—It is surrounded by an *atmosphere* (from *ατμός*, "vapour," and *σφαῖρα*, "a globe,") or envelope of an admixture of gases, which is indispensable to animal and vegetable life.

1. Kosmos; a General Survey of the Physical Phenomena of the Universe, by Alexander von Humboldt. London, 1845. vol. i. p. 174.

2. Ibid. p. 180.

3. Celestial Scenery; or, the Wonders of the Planetary System displayed, by Thomas Dick, LL.D. pp. 60, 152.

5. *Atmosphere revolves with the earth.*—The atmosphere revolves with the earth by the influence of *attraction,* which the latter exerts upon it.

6. Were the atmosphere to cease to be attracted by the earth during the diurnal rotation of the latter on its axis—were it, in fact, to become motionless, and the earth to revolve within it, it would offer a resistance to the movement of the latter which would hurl in one universal desolation every living thing, plant, and habitation of man.

7. *Atmosphere, properties of.*—Fluidity, elasticity, expansibility, gravity, transparency, and invisibility.

8. *Atmosphere, ubiquity and unvarying constitution of.*—The composition of the atmosphere is extremely *uniform*, if not *identical*, *in all parts of the world*, *at all elevations, at all seasons*, and nearly *in all weathers.*

9. *Atmosphere, chemical constituents of.*—Atmospheric air is a *mechanical mixture, not* a *chemical compound,* consisting of 79·2 parts, by *measure*, of nitrogen or azote, and 20·8 parts of oxygen. If the calculation be made by *weight*, there will be in every 100 measures, 77 of nitrogen and 23 of oxygen.

10. According to the atomic theory, atmospheric air is a mixture of one atom or equivalent of oxygen = 8, and two of nitrogen = 14 × 2 = 28.

11. The different gases of which the atmosphere is composed consist of molecules of definite size and form, endowed with self-repulsion: they obey the laws which govern the general *diffusion* of gaseous bodies. The molecules of each gas are equally diffused throughout the whole extent of the atmosphere, and hence its nearly *uniform composition.*

8. Essai de Statique Chimique, 53, by M. J. Dumas.

9. Manual of Chemistry, by W. T. Brande, F.R.S. London, 1848, pp. 368, 370.

10. Ibid. p. 374.

11. Bridgewater Treatise, by William Prout, M.D., F.R.S. London, 1834, pp. 201, 202.

12. *Atmosphere, adventitious ingredients of.*—Minute quantities of other ingredients likewise enter into the composition of the atmosphere, the quantity of which is liable to vary. Of these, *carbonic acid* and *aqueous vapour* are the most constant and important. In 10,000 volumes of air M. de Saussure found only 4·15 (or 3·15 the minimum, 5·74 the maximum) volumes of carbonic acid, or less than 0·1 per cent.

13. The atmosphere contains from one to one and a half per cent. of water in a state of elastic vapour, forming an independent atmosphere, *mixed*, but *not combined with* or *dissolved* in the air. One hundred cubic inches of atmospheric air at 57° of Fahrenheit's thermometer are capable of retaining 0·35 grains of watery vapour: in this state the air may be considered at its maximum of humidity.

14. The quantity of vapour in an aerial atmosphere can never exceed, though it may be less than, the quantity which is proper to the temperature of the air.

15. As an average of results, the ordinary constituents of the atmosphere appear to be in the following proportions:—

Oxygen	19·7
Nitrogen	78·8
Aqueous vapour	1·4
Carbonic acid	·1
	100·0

16. *Atmosphere, accidental ingredients of.* A large amount of ozone *constantly* exists in the atmosphere. It must, however, be considered as one of the *accidental* ingredients, as its quantity is ever varying. Chlorine in small quantities is occasionally met with. Indeed, Dr. Prout suggests "that the atmosphere

13. De Saussure, Dalton, Ure, Brande, Daniell, Prout.
14. Prout, op. cit. p. 293.
15. Brande, op. cit. p. 374.
16. Prout, op. cit. p. 198.

may be conceived to contain a little of everything that is capable of assuming the gaseous form."

17. M. Fresenius has also found that 1,000,000 parts of atmospheric air contain, during the day, ·098 parts of ammonia, a quantity equivalent to 0·283 parts of carbonate of ammonia; and, during the night, 0·169 parts of ammonia, equivalent to 0·474 parts of the carbonate. Much importance is attached to the presence of ammoniacal vapour in the air, as the source of nitrogen in vegetables.

18. The atmosphere of large cities contains also traces of sulphurous and sulphuric acid, sulphate of ammonia, carbonaceous matter, and sulphuretted hydrogen. Minute traces of free hydrogen and carburetted hydrogen (fire-damp, or marsh-gas), incessantly evolved by stagnant waters and marshes, have been observed. In the vicinity of the sea, and especially during storms, the *rain* contains traces of salts; and, during thunder-storms, affords slight indications of nitric acid and nitrate of ammonia.

19. Ten thousand volumes of *dry* air consist of

Oxygen	2,080
Nitrogen	7,912
Carbonic acid	4
Carburetted hydrogen . . .	4
Ammonia, traces of . . .	
	10,000

20. *Atmosphere, contaminations of.*—The composition of the atmosphere may also be deteriorated, and its purity contaminated, by the admixture of *infectious* or *contagious* compounds.

17. Kosmos, vol. i. p. 338. De Saussure, Liebig.

18. Experimental Researches, by Michael Faraday, D.C.L. 3rd Series, § 324. Brande, op. cit. p. 375. Liebig, Arago, De Saussure, Boussingault, Dumas.

19. Chemistry of Creation, by Robert Ellis, F.L.S. London, 1852, p. 230. Dumas, Brunner, Bunsen, Regnault.

Of the former, *malaria*, or *marsh miasma*, and *gaseous exhalations*, the product of putrefactive changes of organic and vegetable substances, are instances. Of the latter, the *effluvia* or *emanations from*, and the *exuviæ of*, the bodies of the sick are examples. From the manner in which these appear to be decomposed and destroyed by chlorine, it is not improbable that they consist of some organic or hydrogenated compounds. Dr. Prout suggests the possibility of some form of selenium being occasionally present in the air, which is productive of catarrhal epidemics.

21. *Atmosphere, occasional presence of foreign bodies in.*—Rain and snow have been coloured by myriads of minute red lichens, *uredo nivalis*, and by other cryptogamous plants; the atmosphere has been loaded with earthy and metallic matters of volcanic origin in a state of extreme comminution. Ehrenberg has shown that the dust with which the atmosphere of the Cape de Verd Islands is frequently charged, contains an infinity of silicious-shelled infusory animalcules.

Aerolites or meteoric stones have been occasionally met with.

22. In the years 1782 and 1783 a *dry fog*, supposed to be of volcanic origin, extended over the whole of Europe, and was believed to occasion epidemic catarrh or influenza, not only in the human subject, but in the lower animals. This fog was the seat, and perhaps the cause, of frequent thunder-storms.

23. *Atmosphere, phosphorescence of.*—The admixture of certain foreign substances with the atmosphere communicates to it the phosphorescent faculty.

24. We are informed by Dr. Verdeil, of Lausanne, that the celebrated dry fog of 1782, 1783, "diffused at night a light

21. Prout, op. cit. p. 347.
Kosmos, vol. i. p. 378.
Aristot. Hist. Animal. vol. xix. p. 552. Bekk.

23, 24. Meteorological Essays, by François Arago, translated under the superintendence of Colonel Sabine, R.A. London, 1855, p. 51.

which permitted objects to be seen at a certain distance, and which extended equally to all parts of the horizon. The light was similar to that of the full moon with a sky generally covered, or when concealed behind a thick but more partial cloud."

The dry fog of 1831 also emitted phosphorescent light.

25. Ordinary fogs in Ireland have been observed by Dr. Robinson, the Director of the Armagh Observatory, to possess phosphorescent properties. At Loch Scavig, in Scotland, Major Sabine saw a cloud, resulting from the precipitation of vapours brought by constant southerly winds from the Atlantic, and which enveloped a high mountain of bare rock, perfectly luminous at night.

26. "Let us regard phosphorescence," says M. Arago, "as a necessary consequence of a gaseous condition and state of cloud; and let us further suppose the sun to be surrounded by a continuous stratum of clouds; and the difficulty will disappear."

27. *Atmosphere, specific gravity of.*—The specific gravity of the atmosphere, at mean temperature and pressure—*i. e.* the thermometer of Fahrenheit being at 60°, and the barometer at 30 inches—is usually considered as = 1.

28. From the latest experiments of Dr. Prout, one hundred cubic inches of pure and *dry* atmosphere, at mean temperature and pressure, weigh 31·0117 grains, so that upon this datum it is about 815 times lighter than its bulk of water, and 11·065 times lighter than its bulk of mercury. Compared with hydrogen, its specific gravity is as 15·2 to 1.

29. A cubic foot of dry air, at 32° Fah. *under mean pressure,* weighs, according to Mr. Glaisher, 566·86 grains.

26. Arago, op. cit. p. 51.

27. Brande, op. cit. p. 363.
Bridgewater Treatise, pp. 350, 351, 352.

28. Ibid.

29. Meteorology, by James Glaisher, F.R.S. &c. London, 1857, pp. 34, 35.

30. The specific gravity of the atmosphere is materially influenced by temperature, and by the amount of aqueous vapour which it contains.

31. The weight of the air is inversely as its volume.

32. In order to ascertain the weight of a cubic foot of *dry* air at any temperature at the sea level, multiply the number of degrees between 32° and the increased temperature by 0·0020361, the amount of expansion of volume sustained by air for each degree of increased temperature. To the product add 1·0, the bulk of the cubic foot of air at 32° Fah. With this number divide 566·86, the weight of a cubic foot of dry air at 32° and under mean pressure; the quotient will be the weight, in grains, of a cubic foot of dry air at the increased temperature.

Thus, Required the weight of a cubic foot of dry air at 55°, at the sea level:—

$55° - 32° = 23° \times 0{\cdot}0020361 = 0{\cdot}0468303 + 1{\cdot}0 = 1{\cdot}0468303$, the increased volume acquired by a cubic foot of air by increase of temperature, $\frac{566{\cdot}86}{1{\cdot}0468303} = 541{\cdot}501$ grains, the weight of a cubic foot of dry air at 55°.

33. *Atmosphere, weight or pressure of.*—That the atmosphere is a ponderous body was suspected by Aristotle and other ancient philosophers, was believed by Galileo, and demonstrated by Blaise Pascal and Evangelista Torricelli.

34. Pascal, in 1646, filled with *water* a glass tube 46 feet in length, hermetically sealed at one end, and inverted the open end in a cistern of the same fluid. The water in the tube, after its oscillations had subsided, was sustained at a height of 34 feet above the surface of that in the reservoir. Torricelli, in the same year, filled a tube, three feet long, with *mercury*, and plunged the open end in a vessel of that metal. The mercury in the tube fell to about 30 inches above the level of that in the basin.

32. Glaisher, op. cit. pp. 34, 35.

35. It was thus ascertained that the column of *water* 34 feet high, as well as that of the *mercury* 30 inches high, exactly counterpoised a column of air of an equal base, extending from the sea level to the top of the atmosphere. And further, that as a column of mercury 30 inches high, every one of whose sides measures one inch, weighs nearly 15lbs., or, more accurately, 14·75lbs. so a column of air, with its aqueous vapour, of like area, extending from the surface of the sea to the top of the atmosphere, *presses* upon the former with a weight of 14·75lbs.

36. Pascal, in 1647, originated the idea, and was the first to observe, that if the atmospheric pressure were diminished or increased by any disturbing causes, by rarefied or by denser atmosphere, by elevation or descent, the mercury in the tube would fall or rise in a corresponding degree.

37. The Barometer, the name by which the instrument invented by Torricelli is known (from *βαρος* "*weight*" and *μετρον* "*measure*"), is therefore employed to measure the heights of mountains and other elevated localities. This would, indeed, be a very simple matter were the atmosphere, in ascending from stratum to stratum, *homogeneous*, or of *one uniform density;* for, as a column of mercury 30 inches high has the same weight as a column of air of an equal base, extending *from the level of the sea to the top of the atmosphere* (35), and as the weight of the mercury, bulk for bulk, is 11,065 times greater than that of air (28), it results that the height of a column of air, as *heavy as the column of mercury*, must be 11,065 times greater than the latter, or 27662·5 feet, or 5·2391 miles.

38. But as it will be shown that the height of the atmosphere extends from 45 to 50 miles (99 to 107)—indeed it has been said to exceed 75 miles—it is evident that, in order to construct a formula for ascertaining the heights of mountains, &c. it is necessary to take into account—

1st. The diminution of the weight of the air from rarefaction and its increasing distance from the earth;

2nd. The difference of temperature at the upper and lower points of observation;

3rd. The variation of elastic force both from rarefaction and change of temperature;

4th. The alteration of density in the mercury itself from decrease of temperature;

5th. The variation of the force of gravity at different elevations;

6th. The latitude of the places of observation.

39. As the *weight* of the column of air at the upper station is *diminished* in proportion to the amount of elevation, so is the *height* of the column of mercury *lessened* in a corresponding degree.

40. Did the temperature and force of gravity remain unaltered, and were the density of the air the same at all heights, the logarithms of the atmospheric pressures corresponding to different altitudes would *decrease* in arithmetical progression as the pressures themselves decrease, and as the altitudes *increase* in arithmetical proportion.

But as the pressure taken off by the ascent is derived from that portion of the atmosphere which is the most dense, and at which the force of gravity is the greatest, this must be considered in the construction of the formula.

41. Laplace, Lindenau, Ramond, Trembley, Roy, Deluc, Shuckburgh, and others, have given us formulæ for ascertaining, with as much accuracy as possible, the heights of elevated localities.

Of these that of Laplace is the most exact; that of Sir George Shuckburgh the most simple.

42. By the former, the temperature of the atmosphere between the upper and lower stations is treated as if it had throughout a mean between the two.

39. Knight's Penny Cyclopædia, article "Heights, Measurement of," vol. xii. p. 100.

42. Poisson, Mécanique, 2nd edition.

Let h and h' be the heights of the barometer at the lower and upper stations; t and t' the temperatures of the air; T and T′ those of the mercury; r the radius of the earth, supposed to be 6,962,283 yards, and λ the latitude of the place.

$$\text{Let } k = h\left(1 + \frac{T - T'}{9990}\right)$$

$$c = \frac{20053\cdot95}{1 - \cdot002588 \cos. 2\lambda}\left(1 + \frac{t + t' - 64}{900}\right)$$

$$z = c\,(\log. h - \log. k).$$

Then z is a near approximation, in yards, to the difference between the two stations; but, if greater accuracy be required, then, using z as just found,

$$c\left(\log. h - \log. k + 2\log.\left(1 + \frac{z}{r}\right)\right)\left(1 + \frac{z}{r}\right).$$

If the lower be at a great distance on the earth's surface from the upper station, five-eighths only of $\frac{z}{r}$ are to be used.

For ordinary purposes the following formula by Mr. Ramond will be found sufficient:—

$$20115\left(1 + \frac{t + t' - 64}{900}\right)(\log. h - \log. h').$$

43. Sir George Shuckburgh's formula:—

Let x be the height of the mountain required; A the *mean height* of, and a the *difference* between, the two barometers; b the factor corresponding to the *mean* height of the two thermometers.

$$\text{Then } \frac{30 \times a \times b}{A} = x.$$

Thus, if the barometer at the lower station be 30 inches, and the thermometer 65°; the barometer at the upper station 24·93 inches, and the thermometer 49°; the mean of the two barometers will be 27·465 inches, and their difference 5·07

inches; the mean of the two thermometers 57°, of which the corresponding factor is 921·4:—therefore

$$\frac{30 \times 5{\cdot}07 \times 921{\cdot}4}{27{\cdot}465} = 5102 \text{ feet.}$$

44. Table of *Factors* employed in Sir George Shuckburgh's formula, corresponding to the mean temperature of the upper and lower stations, deduced from the number of feet in a column of the atmosphere equivalent in weight to a column of mercury of equal base, one-tenth of an inch high, the barometer standing at 30 inches.

Thermometer.	Factor.	Thermometer.	Factor.	Thermometer.	Factor.
30°	864·4	47°	900·2	64°	936·1
31	866·5	48	902·3	65	938·2
32	868·5	49	904·5	66	940·3
33	870·6	50	906·6	67	942·4
34	872·7	51	908·7	68	944·5
35	874·9	52	910·8	69	946·7
36	877·0	53	913·0	70	948·8
37	879·2	54	915·1	71	950·9
38	881·3	55	917·2	72	953·0
39	883·4	56	919·3	73	955·1
40	885·4	57	921·4	74	957·2
41	887·5	58	923·5	75	959·3
42	889·6	59	925·6	76	961·4
43	891·7	60	927·7	77	962·5
44	893·8	61	929·8	78	965·6
45	896·0	62	931·9	79	967·7
46	898·1	63	934·0	80	969·9

45. For the sake of uniformity and comparison it is usual to reduce the readings of the barometer to 32° of Fahrenheit's scale. This is done by subtracting the ten-thousandth part of the observed altitude for *every degree* by which the mercury is above the freezing point; the expansion of mercury, for each degree of Fahrenheit's thermometer being ·0001 of its bulk, at 32°.

46. Corrections, in the following ratio, for capillarity of tubes, are also to be *added* to the observed height of the mercury:

Inner diameter of tube.		Corrections for capillarity.
0·1 inch	=	0·070 inch
0·2 ,,	=	0·029 ,,
0·3 ,,	=	0·014 ,,
0·4 ,,	=	0·007 ,,
0·5 ,,	=	0·003 ,,
0·6 ,,	=	0·002 ,,

47. A further correction, for index-error, is necessary. The index error, which is the difference between the true readings and those given by the barometer, varies with every instrument, and can only be ascertained and determined by means of a comparison with a standard barometer.

48. In the absence of formulæ and factors, it may be assumed, in order to arrive at an approximative height of a given locality, that, at the sea level, the mean density or pressure of the atmosphere is equal to the support of a column of mercury 30 inches high (35), and that the barometric column falls about one-tenth of an inch for every hundred feet, or about one inch for every thousand feet of ascent.

				Inches.		Inches.
Thus, at 1000 feet	above the surface	the column	falls	1·09	*i.e.* to	28·91
2000	,,	,,	,,	2·14	,,	27·86
3000	,,	,,	,,	3·15	,,	26·85
4000	,,	,,	,,	4·13	,,	25·87
5000	,,	,,	,,	5· 7	,,	24·93
1 mile	,,	,,	,,	5·33	,,	24·67
2	,,	,,	,,	9·71	,,	20·29
3	,,	,,	,,	13·32	,,	16·68
4	,,	,,	,,	16·28	,,	13·72
5	,,	,,	,,	18·72	,,	11·28
10	,,	,,	,,	25·76	,,	4·24
15	,,	,,	,,	28·40	,,	1·60
20	,,	,,	,,	29·50	,,	0·95

Thus, one half of the whole mass of the atmosphere lies

46, 47. Glaisher, op. cit.

48. Brande, op. cit. p. 361.

within three miles and a half, and four-fifths within eight miles, of the sea level. Dr. Prout, however, says, that "by far the greater portion of it is always within fifteen or twenty miles of the earth's surface."

49. Fluctuations in the density and pressure of the atmosphere, influence the boiling point of water. For every inch of variation of the barometric column, the boiling point of water varies 1·76° Fah., consequently every tenth of an inch which the barometer rises or falls elevates or depresses the boiling point by about 0·176° Fah.

50. It occurred to Mr. Fahrenheit that advantage might be taken of this fact to ascertain the height of mountains; and with this view he proposed that, in order to find the difference, in feet, between the upper and lower stations, pure water should be boiled in an open vessel at both stations, and the *difference* of temperature at which it boils should be multiplied by 530, which will give a close approximation to the height of the upper above the lower station. From the *conjoined* temperatures of the atmosphere at the two stations 64° are to be subtracted, and the remainder is to be multiplied by the one-thousandth part of the height already found, to which it is to be added. This is the correction for the difference of the temperature at the two stations. A further correction is necessary for the figure of the earth, and the latitude of the place. This amounts, in our latitudes, to an addition of about two feet in every thousand of the calculated elevation.

This method has received from the Rev. F. J. H. Wollaston the highest degree of perfection of which it seems capable.

Water boils on Ben Nevis, lat. 56·46 N., at 203·8°, and at the side of the Caledonian Canal at 212°. The temperature

48. Bridgewater Treatise, p. 199.
50. Barometri novi descriptio, Phil. Trans. vol. xxxiii.
Encyclopædia Britannica, article "Steam."
Phil. Trans. 1817, p. 192.

of the atmosphere at the upper station is 30°, and of the lower station 35°; then

Temp. of Water . . 212° − 203·8° = 8·2° × 530 = 4346 approx. height.
Temp. of Atm. . . 30° + 35° = 65° − 64° = 1 × 4·346 = 4 + 4346 = 4350.
Latitude . . . . . 4·350 × 2 = 8·700 + 4350 = 4358·7 height of Ben Nevis.

The actual height of Ben Nevis by measurement is 4,358 feet.

M. de Saussure, 3rd August, 1787, found water boil on the summit of Mont Blanc at 68·993° Reaum. = 187·099° Fah.; the thermometer at noon, suspended four feet above the summit, in the shade, was − 2·3° Reaum. = 26·825° Fah.; the reading of the barometer three feet below the summit being 16 inches $\frac{144}{160}$ of a line, correction being made for the condensation of the mercury by cold.*

51. Hitherto we have been dealing with the water barometer of Pascal, and the mercurial barometer of Torricelli. We have now to speak of the *aneroid barometer*, the invention within the last few years of M. Vidi, a Frenchman.

The aneroid barometer (from ἄνευ, "*without*," ῥοώδης, "fluid,") consists of a flat circular metallic box, 4¾ inches in diameter, and 1¼ inches thick, containing an *exhausted* copper drum, of which the corrugated upper plate or head is exceedingly thin. From the centre of this upper plate springs an upright metallic shaft, which, as it rises or falls by the varying amount of *atmospheric pressure* exercised on the drum-head, multiplies, by means of levers and springs of an ingenious and complicated workmanship attached to its upper end, the delicate movements thus propagated to it, and which are marked by an index traversing a dial graduated to correspond in inches and tenths with the scale of the mercurial barometer.

For portability, the aneroid possesses an advantage over the

* Voyage dans les Alpes, par Horace Benedict de Saussure. Neuchatel en Suisse, 1804, vol. iv. p. 207.

mercurial barometer, but for scientific purposes can never supersede the latter. The aneroid is exceedingly sensitive, and, when properly adjusted, as accurate as sensitive.

52. Mr. Roger Cotes computed the *pressure* of the atmosphere on the whole surface of the earth, to be equivalent to that of a globe of lead sixty miles in diameter.

53. M. Dumas has estimated its *entire weight* as equal to 581,000 cubes of copper, one kilometre in the side.

Professor Schmid, of the university of Jena, has calculated it, omitting its watery vapour and carburetted hydrogen, at 1,371,977,266,659,000,000lbs. or 12,249,797,023,741,071cwts. or 612,489,851,187,053 tons.

54. The *total quantity* of the atmosphere has been estimated at a little less than the millionth part of the whole mass of the earth, supposing the mean density of the latter to be five and a half times greater than that of water.

55. The effects of the ordinary pressure of the atmosphere upon animal life, are most important to the due performance of the functions of the various organs of which the body is composed, and a first essential to a healthy condition of the whole animal economy.

56. The body of an average-sized man presents a surface of about 2,160 square inches, or fifteen square feet, and consequently sustains, at the sea level, a total pressure of 32,400 lbs. or nearly fourteen tons and a half. Owing, however, to the *equal transmission or propagation of pressure in all directions*, a property common alike to air, water, and all fluids, we are totally unconscious of this enormous weight. By this pressure, exerted uniformly over every point of the

53. The Chemical and Physiological Balance of Organic Nature, by M. J. Dumas and M. J. B. Boussingault, London, 1844, p. 19.

The length of the kilometre has been ascertained by Capt. Kater (Phil. Trans. 1818) to be 39370·788 English inches, or very nearly five English furlongs (39,600 inches). The kilometre is equal to a mean centesimal minute of the earth's polar circumference.

54. Poisson, Mécanique, 2nd edit. vol. ii. p. 60.

body, the corporeal framework is more firmly knit together; the lungs are kept charged with air, and follow the expansion of the walls of the chest during inspiration, and adapt themselves to their contraction during expiration.

57. A curious result of the independent condition of the gaseous principles of the atmosphere, consequent upon their observance of the laws of *diffusion* (11), ascertained by Dr. Dalton and Mr. Graham to govern all gaseous bodies, is, that of the thirty inches of mercury supported by the whole atmosphere (35), *each principle* exerts its *own force according to its quantity*, thus the

Nitrogen sustains	23·36	inches.
Oxygen	6·18	,,
Aqueous Vapour	·44	,,
Carbonic Acid	·02	,,
	30·00	

58. *Atmosphere, density of.* As we ascend into the upper regions of the air, we find also the *density* of this elastic fluid to become gradually less and less, in consequence of the quantity of air above each successive stratum being constantly diminished, and the superincumbent weight pressing upon the lower strata being continually reduced.

59. The density of the atmosphere is in proportion to the force which compresses it, or to its elasticity.

60. The density and dryness of the atmosphere are greatest at the poles, and least at the equator.

61. If altitudes be taken from the earth's surface in arithmetical progression, the density of the air decreases in geo-

57. Bridgewater Treatise, p. 199.

59. Mariotte.

61. Synopsis of Practical Philosophy, by Rev. John Carr, M.A. London, 1843, p. 31.

Epitome of the Elementary Principles of Natural and Experimental Philosophy, by John Millington. London, 1823, p. 108.

metrical progression. For instance, one cubic foot of air taken at the sea level would, at an elevation of

Miles.	Cubic Feet.
3½ occupy a space of	2
7	4
14	16
21	64
28	256
35	1024
42	4096
49	16384
56	65536
63	262144
70	1048576

62. Mr. Brande differs somewhat from the above. "At a height," says Mr. Brande, "of 2·705 miles, one volume of the atmosphere would expand into two, its calculated density being diminished at that height by one-half; the density is again halved at every 2·7 miles additional elevation, as in the following table:"—

Height above the sea in miles.	Volume.
0	1
2·705	2
5·410	4
8·115	8
10·820	16
13·525	32
16·230	64
18·935	128

63. *Atmosphere, rarefaction and condensation of.*—The ratio of the spaces occupied by a given quantity of air in its greatest state of rarefaction, is to the same under the highest degree of condensation as 550,000 to 1.

62. Brande, op. cit. p. 361. 63. Carr, op. cit. p. 30.

64. The elasticity of the air is inversely as the pressure acting upon it. Thus a volume of air = 100 under any given pressure, will be diminished to 50 when that pressure is doubled; and expanded to 200 when the pressure is diminished by one-half.

65. Atmospheric air, on being *condensed* thirty times, has its capacity for heat reduced to one-half; and, if suddenly *compressed* to twenty times its *ordinary density*, will disengage heat enough to show an elevation of temperature equal to 900 degrees of Fahrenheit's scale, and sufficient for the inflammation of most bodies. An opposite effect takes place when air is suddenly *rarefied*, a certain quantity of heat being now absorbed, or an apparent cold produced.

66. *Rarefaction* does not considerably *diminish* the heat of flame in atmospheric air, neither does *condensation* much *increase* it.

67. At all the heights or depths at which man can exist, the atmosphere still preserves the same relation to *combustion*.

68. *Atmosphere, temperature of.*—The solar rays permeate the atmosphere almost without affecting its temperature. The surface of the earth absorbs the solar heat, and recommunicates it to the immediately superincumbent stratum of air, which is generally identical with that of the surface itself.

69. Dr. Wells is of opinion "that the air arrests part of the sun's heat, which is radiated into it bound up with light, and that it is actually heated by the sunbeams which enter it." "Air," he says, "absorbs, reflects, and refracts the sun's light." And, in corroboration of his views, he adduces "the

64. Brande, op. cit. p. 380.
Boyle and Mariotte.
The Relations of Air to Heat and Moisture, by John Leslie. Edinburgh, 1813, p. 3.

68. Prout, op. cit. p. 270.
Leslie, op. cit. p. 3.

69. An Essay on Dew, by William Charles Wells, M.D. 1818, pp. 217, 218.

great warmth of the air, after a long calm, incumbent on the Atlantic and Pacific oceans, at the distance of thousands of miles from any considerable body of land, which cannot be derived from the water, as this is colder than the lower stratum of atmosphere, which last is, moreover, cooled every night, and again becomes warm in the day."

70. The temperature and centrifugal force of the atmosphere are at their maximum at the equator, and at their minimum at the poles.

71. Humboldt has fixed the mean equatorial temperature at the level of the sea at 81·5°. He has frequently found the thermometer, when placed on the ground, has indicated a temperature of 129°, and, on one occasion, it marked upwards of 140°; the thermometer in the sun, at the same time, only indicating a temperature of about 97°.

Mr. Atkinson found the mean temperature at the equator to be at least equal to 84·5°. Sir David Brewster considers it to be only 80·99°.

72. *In no place on the earth's surface, nor at any season*, will a thermometer, raised two or three yards above the soil, and sheltered from all reverberation, attain to 114·8° Fahrenheit.

73. *On the open sea* it will never attain to 87·8° Fahrenheit.

74. The temperature of the *water of the ocean in any latitude*, or *at any season*, never rises above 86° Fahrenheit.

75. There is less variation in the temperature of the sea than of the air.

76. The *greatest degree of cold* ever observed on our globe *in the air*, is 58° below zero of Fahrenheit.

77. The *greatest degree of cold* produced *artificially* has been 91° below zero.

71. Memoirs of the Royal Astronomical Society, vol. ii.
Edinburgh Journal of Science, vol. vi.

72. Annales de Chimie, xxvii. 432.

76. Ibid. This reading has been said to admit of some doubt, and that, possibly, it was not accurately recorded.

78. The thermometer in Captain Parry's ship at Melville Island was often observed as low as $-50°$; and, at a distance from the ship, even as low as 55° below zero.

79. *Isothermal lines*, or lines of equal temperature.—Humboldt has shewn that the earth is encircled by many lines, each of different temperatures, but that the temperature of each line is identical throughout. To these lines the name of Isothermal has been applied. These lines for the most part do not run parallel to each other, but approximate to and diverge from each other in a peculiar and capricious manner, "their course being especially influenced by the relations of extent and configuration between the opaque continental and the fluid oceanic masses."

80. The Isotherm of 32°, commencing at the Great Slave Lake in North America, 61° 30′, pursues an eastward course, crosses the lower part of Hudson's Bay, 52° 15′, passes about four degrees south of Nain, on the coast of Labrador, 52° 20′, ascends to one degree north of Umea in Sweden, 66°, and is next found at North Cape in Norway, 71° 10′, whence it makes an abrupt descent, and attains its lowest limit in the eastern part of Siberia, beyond which its course has not been traced.

81. The Isotherms within the torrid zones run nearly parallel to the equator and to each other.

82. *Mean temperature.*—By mean temperature is understood that temperature which is equidistant from the extremes. That of the day is found by adding together the results of all the observations, and by dividing the sum by the number of observations. In the same manner are obtained the *mean temperatures* of the week, month, season, and year.

83. In mid-Europe, between the parallels of 38° and 71°, the temperature increases in a constant proportion with lessening latitudes, and diminishes in the same proportion with

78. Journal of a Voyage for the Discovery of a North West Passage, 1821; p. 145.
79. Kosmos, vol. i. p. 345.
83. Ibid. p. 359.

increasing latitudes. This increase, as well as decrease, is equivalent to 0·9° Fah. for each degree of latitude.

Beyond these parallels, either towards the pole or the equator, the increase and decrease of temperature are no longer in constant proportions.

84. On the eastern coasts of North America, from the 54th to the 42nd north parallel, the temperature increases 1·584° Fah. for every degree; from the 42nd to the 32nd 1·71° Fah.; from this to the 21st only 1·188°; and from the 21st to the 10th parallel, the increase is no more than 0·36° Fah.

85. The difference of mean temperature between summer and winter is nothing at the equator, but increases constantly as we approach the poles.

86. *Formulæ* for finding the *mean temperature,* at the level of the sea, of any given latitude.

$$t = 58° + 27° \times \cos. 2 \text{ latitude.—Fahrenheit.}$$

When 2 latitude is greater than 90°, cos. 2 lat. is negative.
Playfair.

$$t = \cos.^2 \text{lat.} \times 29°. \quad \text{Centigrade.—}\textit{Leslie.}$$

$$t = 97{\cdot}08° \times \cos. \frac{3}{2} \text{lat.} - 10{\cdot}53°. \quad \text{Fahrenheit.—}\textit{Atkinson.}$$

87. In ascending from the level of the sea, the temperature of the atmosphere decreases nearly uniformly.

Leslie calculates the diminution of heat at the rate of 1° Fah. for every 300 feet near the earth's surface; and, at one, two, three, four, and five miles altitude, 295, 277, 252, 233, and 192 feet respectively, for every degree of Fahrenheit. According to Playfair, the diminution of heat, near the earth's surface, is 1° Fah. for every 270 feet of ascent. Mr. Atkinson makes the decrease equal to 1° Fah. for every 251·5 feet of

84. Kosmos, vol. i. p. 359.
87. Leslie, op. cit. p. 12.
Memoirs of Royal Astronomical Society, vol. ii.
Kosmos, vol. i. p. 389.

perpendicular rise. Humboldt states that in mid-Europe, between the parallels of 38° and 71°, the diminution of temperature is 0·9° Fah. for every 240 or 262 feet of perpendicular elevation above the level of the sea.

88. Gay Lussac, at an elevation of 22,902 feet above the level of the sea, found the temperature to have diminished as much as 72·5° of Fahrenheit. This, supposing the decrease of temperature to be uniform, gives a diminution of 1° Fah. for every 315 feet of elevation. The fall is, however, more rapid in the higher than in the lower regions, in consequence of the increased capacity for heat possessed by air, in proportion as it becomes more rare (65). In that part of the Andes which lies within the tropics, Humboldt found Fahrenheit's thermometer indicated a fall of 0·9° for every 288 feet of perpendicular elevation.

89. Lindenau, Euler, and Oriani suppose the temperature of the atmosphere to diminish in harmonic progression through a series of heights increasing in arithmetical proportion.

90. The mean results of a great number of observations, made in different parts of the world, appear to show, that for every 300 feet of altitude Fahrenheit's thermometer *sinks one degree.*

91. Contrary, however, to the general rule, it has been ascertained by M. Pictet, Mr. Six, and Dr. Wells, that on *clear and calm nights* the temperature of the atmosphere *increases* with the distance from the earth. Mr. Six has established the fact that the atmosphere at the height of 220 feet is often, upon *such nights*, 10° warmer than that 7 feet above the ground. This is accounted for by the earth's surface radiating a portion of the heat acquired during the day, thereby occasioning the deposition, in the form of dew, of a portion of the aqueous vapour suspended in the superincumbent atmosphere.

88. Kosmos, vol. i. p. 360.
91. Wells, op. cit. p. 200.

92. The temperature of the atmosphere at all elevations is inversely as the capacity of air possessing the rarity due to the given altitude.

The same absolute measure of heat exists at all heights. Its apparent decrease proceeds wholly from that enlargement of capacity which the attenuated fluid acquires (65).

93. For every additional degree of heat air expands, and for every degree of diminished temperature, contracts $\frac{1}{491{\cdot}13}$th, or 0·0020361 part of its bulk. It therefore expands 0·3665 of its bulk from 32° to 212°. Between these points its expansion is uniform.

94. As an illustration of the foregoing calculations, we may instance the Hospice of the Grand St. Bernard, 7,668 feet above the sea level, in 45° 51′ N. lat., of which last the mean annual temperature is 57·65°. Required, the mean annual temperature of the Hospice, and the place, the mean annual temperature of which at the sea level will coincide with that of the Hospice.

Divide the height of the Hospice, 7,668 feet, by 300, which number of feet produces a fall of 1° of Fahrenheit's thermometer (90) = 25·56 × 1° = 25·56° Fah., which being subtracted from 57·65°, gives 32·09° for the *mean annual temperature* of the Hospice, which coincides very nearly with that of the Pole.

Again, it has been stated (83), on the authority of Humboldt, that between the 38th and 71st parallels the temperature varies 0·9° Fah. for each degree of latitude. On reference to the table of mean temperature (98), it will be seen that between 40° and 70° this variation is only 0·8°; between 70° and 80°, 0·453°; and between 80° and 90° only 0·157°, for each degree of latitude.

93. Glaisher, op. cit. p. 33.

$$\begin{aligned} \text{Thus, } 70^\circ - 45{\cdot}51^\circ &= 24{\cdot}49^\circ \times 0{\cdot}8^\circ &&= 19{\cdot}59^\circ \\ 80^\circ - 70{\cdot}0^\circ &= 10{\cdot}00^\circ \times 0{\cdot}453^\circ &&= 4{\cdot}53^\circ \\ 90^\circ - 80{\cdot}0^\circ &= 10{\cdot}00^\circ \times 0{\cdot}157^\circ &&= 1{\cdot}57^\circ \\ & && \overline{ 25{\cdot}69^\circ} \end{aligned}$$

which, subtracted from 57·65°, gives 31·96° as the mean annual temperature of the spot, which coincides with that of the Hospice.

95. *Line of Perpetual Congelation, or Snow Line.*—The law which connects the capacity with the rarity of air being ascertained, the gradations of cold in the higher atmosphere are easily traced, and the precise limit determined where the reign of perpetual congelation must commence.

96. "The law of the decrement of temperature corresponding with the height above the sea level under different parallels of latitude, is," says Humboldt, "one of the most important particulars in connection with the knowledge of meteorological processes, the geographical distribution of plants, the theory of terrestrial refraction, and the various hypotheses which bear upon the determination of the height of the atmosphere."

In every latitude there is a certain height where the mean temperature is below 32° Fah. This is the region of eternal snow. The curve connecting all these points is called "*the line of perpetual congelation.*"

97. The line of perpetual congelation, or the "*snow line,*" varies in every latitude.

The following formula, by Playfair, will give its height in all latitudes:—

$$H = 7642 + 7933. \cos. 2 L.$$

95. Kosmos, vol. i. p. 171.
96. Carr, op. cit. p. 35.
Leslie, op. cit. p. 13.
Elements of Geometry, pp. 495, 496.

98. TABLE of *mean temperature* at the level of the sea, and of the *height of the curve of congelation*, in different latitudes, computed from Leslie's formulæ.

Latitude.	Mean Temperature, Fahrenheit.	Height of Curve of Congelation, in feet.	Latitude.	Mean Temperature, Fahrenheit.	Height of Curve of Congelation, in feet.
0°	84·200°	15207	54°	50·029°	5290
5	83·803	15095	55	49·168	5034
10	82·623	14764	56	48·317	4782
15	80·702	14220	57	47·477	4534
20	78·093	13478	58	46·657	4291
25	74·876	12557	59	45·843	4052
30	71·150	11484	60	45·050	3818
35	67·026	10287	65	41·515	2722
40	62·632	9001	70	38·102	1778
45	58·100	7671	75	35·675	1016
50	53·558	6334	80	33·571	457
51	52·671	6070	85	32·396	117
52	51·774	5808	90	32·000	00
53	50·905	5548			

99. *Limit of the atmosphere.* It is more than probable that the extreme limit of the atmosphere, *revolving with the earth*, does not extend beyond 45 or 50 miles, at which height the air is supposed to have lost its elasticity, and to be terminated by a definite surface, similar in form to that of the earth itself.

100. The balance between the forces of elasticity and the earth's attraction, may be considered as the real limit of the atmosphere.

101. Refraction ceases at about 45 miles, a proof that the sensible atmosphere does not extend much beyond that distance. At least, if it exist higher up, it is so exceedingly rare as to have no effect in deflecting a ray of light.

102. The arguments of Dr. Wollaston furnish a very strong

99. Wollaston, Phil. Trans. 1822, p. 89.

100. Ellis, op. cit. p. 172.

101. Elements of Chemistry, by Robert Kane, M.D., M.R.I.A. Dublin, 1841, p. 439.

presumption in favour of the finite extent of the atmosphere. But supposing the particles of atmospheric air capable of division to an infinite degree throughout all space, it by no means follows that this attenuated medium is common air, or anything approaching to it, in the proportion of its density to its elastic power.

103. Again, as the several strata of the atmosphere must, as they recede from the earth's axis, necessarily revolve with a velocity infinitely greater than that at the level of the sea, it would result that the centrifugal force at the equator, at high elevations, would speedily overcome the attraction of gravity, and cause the molecules composing the atmosphere to fly off.

104. Another supposition in favour of a *finite* atmosphere is derived from the rapid *decrease of temperature* which takes place as we recede from the surface of the earth (87, 88, 90). Assuming that every 600 feet of elevation produces a fall of only one degree of Fahrenheit's thermometer, it follows that, at a height of forty miles above the sea level, the temperature of the air would be 350° of Fahrenheit below that of the sea, or certainly more than 300° below the freezing point. No gas with which we are acquainted would preserve its gaseous state at this low temperature, but would become liquid.

105. Poisson, however, considers it possible that as all gases, by reduction of temperature, may be rendered solid, so may the atmosphere, by becoming more attenuated, and more and more cold, attain to a point at which it would freeze; and, in accordance with this theory, he advances the supposition that the uppermost surface of the atmosphere is covered by a transparent pellicle of ice.

106. The temperature of *space* has been computed by Baron Fourier and other philosophers to be about —57°, —58° of Fahrenheit's scale, or 90° below the freezing point of water; a

105. Poisson, op. cit.

106. Fourier, Théorie de Chaleur.

temperature only two or three degrees lower than that which has been often observed at Melville Island by Captain Parry (78), and not exceeding that which has been recorded by others (76).

107. Poisson's supposition is therefore visionary and untenable.

108. It may be laid down that, so far as animal life is concerned, the limits of the atmosphere do not exceed three miles. Beyond this, the rapidity of the movements of the circulatory and respiratory systems would speedily wear out the machinery and exhaust the powers of life.

109. De Luc, however, attained in a balloon to the height of 20,000 feet = 3·787 miles; and Gay Lussac reached an altitude of 22,902 feet = 4·337 miles above the level of the sea. It must be borne in mind that *no physical exertion* was necessary to their ascent; had it been, their attaining to these elevations would have been simply impossible.

110. *Atmospheric tides.*—The atmosphere has its tides and currents like those of our great oceans. These are apparently of two kinds; the one the result of the heat of the sun's rays, the other of the attraction of the moon.

111. Throughout the world there are two daily atmospheric tides.

Within the tropics the *flow* of the atmospheric tide, according to Humboldt, takes place with the greatest regularity at 9 or 9¼ A.M., and at 10 or 10¾ P.M.; and the *ebb* at 4 or 4¼ P.M., and at 4 A.M. The latter is attributed to the expansion of the air during the hottest part of the day; the former to the pressure of the masses of cool air.

If the height of these tides be proportional to the difference between the specific gravity of air and mercury, the morning tide will be about 13 feet, and the evening tide 25 feet.

111. Kosmos, vol. i. pp. 341, 188.
Thomson, on Heat, p. 240.

With so much regularity do these changes take place, that the time of day may be ascertained by the oscillations of the mercurial column without much chance of error.

112. The regularity of this ebb and flow of the atmosphere within the tropics is not disturbed by tempests of thunder or of wind, or by rain, or by earthquakes.

113. The amount of the daily fluctuation of the barometric column consequent upon the varying pressure of the atmosphere diminishes, by 1·32 line, to 0·18 line, from the equator to 70° north latitude. Much nearer the pole the mean height of the barometer is actually less at 10 A.M. than at 4 P.M.

114. The mean height of the barometer is somewhat less under the equator and the tropics than in the temperate zone. It appears to attain its maximum in the West of Europe in the parallels of 40° and 45°.

115. *Lunar atmospheric tide.*—The fact of a lunar atmospheric tide has been fully and satisfactorily proved.

116. *Atmospheric Waves.*—The existence of atmospheric waves has been indisputably established. These peculiar movements of the atmosphere would appear to involve its entire mass; to occupy several days in their passage; to recur, both in Europe and America, for the most part, in October or November; and to be attended by calm, serene, warm summer-like weather. Their movements are sensibly felt by the barometer.

On the 9th of October, 1849, the anterior trough of a wave passed over London; the crest on the 13th, and the posterior trough on the 18th. On this day the reading of the barometer was 1·333 inch less than on the passage of the crest. In November following the crests of three other waves passed; one on the 12th, another on the 20th, and the third on the 27th. The readings of the barometer were respectively 30·31, 30·21,

113, 114. Kosmos, vol. i. pp. 341, 342.

117. Meteorology of London, by James Glaisher, F.R.S. 1855, p. 41.

and 30·11 inches. The posterior troughs passed on the 16th, 22nd, and 29th; the readings were successively 29·06, 28·99, and 29·26 inches.

117. *Winds.*—Winds are currents of the air similar in kind to those of the waters, and are for the most part produced by *unequal heating*.

118. They tend to equalize the temperature of the surface of the globe.

119. Winds may be divided into *constant*, *periodical*, and *variable*.

120. The general currents of the atmosphere depend principally on the disproportionate temperature of the equator and of the poles; and on the diurnal rotation of the earth on its axis.

121. The mean temperature of the equator has been shown to be upwards of 81° Fah. (71); that of the poles to be constantly below 32° Fah. (70, 98). Hence, as the atmosphere of the equator is expanded and rendered specifically lighter by heat, so the colder and heavier atmosphere of the poles rushes towards the equator in a perpendicular direction, to supply its place; the lighter equatorial air so displaced ascends to the top of the atmosphere and flows towards the poles. The rotation, however, of the earth on its axis from west to east, deflects, on account of the increased velocity of the parallels of latitude near the equator, which have greater radii than the arctic parallels, the currents of polar air from their northern and southern course, and produces, on the north side of the equator, a north-easterly current, and, on the south side of the equator, a south-easterly current, both of which, as they approach the equator, gradually become more nearly parallel to it, or east. To these the name of "*Trade* Winds" has been given. To the lighter equatorial currents, whose general

120. Prout, op. cit. p. 276.

121. Ibid. p. 277.

Physics of the Earth, by Henry Buff, edited by A. W. Hoffmann, Ph.D., F.R.S. London, p. 215.

direction is towards the poles, the name of *upper* or *returning trade winds* has been assigned. In their progress onwards these take a more and more *westerly* direction, from the same cause which produced in the polar air an *easterly* course, the rotation of the earth, until they become nearly west.

122. Westerly, or W.S.W. winds, in both temperate zones, are, therefore, the prevailing counter currents to the trade or east winds of the tropics.

123. The north-east trade wind blows between 9° and 27° north latitude; and the south-east trade wind prevails between 3° north latitude and 25° south latitude.

124. A belt of five or six degrees of latitude in breadth, the *region of calms*, separates the opposite lower trade winds. Here calms and rains prevail, sometimes alternating with the most frightful storms, caused probably by the mingling and ascending of the opposite aerial currents. This zone of calms, the hottest of the earth, exercises a powerful influence in the production of the trade winds.

125. *Periodical winds, or monsoons.*—These winds blow half the year in one direction, and half the year in the opposite direction. These and the *constant* winds blow only *at sea*. High lands change or interrupt their course, and hence, *on land,* the wind is always *variable.*

126. These periodical winds are only a modification of the trade winds, produced by the peculiar form of the countries lying within and around the Indian Ocean.

127. The *north-east* monsoon blows from October to April, and the south-east monsoon from April to October.

128. *Whirlwinds.*—Whirlwinds are violent movements of the atmosphere in a circular or spiral direction about an axis, the latter having at the same time a progressive motion, rectilinear or curvilinear, on the surface of the land or sea.

122. Kosmos, p. 350.
123. Buff, op. cit. p. 220.

129. Whirlwinds arise when two winds are blowing near each other in opposite directions. The more powerful wind will by degrees draw into its own movement the weaker current, which first, however, suffers a certain amount of condensation: the greater the degree of this condensation, the greater will be the speed with which this weaker current will be drawn into the more powerful movement; and, being continually turned from its course, and always in the same direction, it must of necessity take a twisting, whirling, or gyratory motion.

130. *Storms.*—These are whirlwinds moving onwards in a certain direction.

131. *Hurricanes* or *tornados.*—These arise where the belt of the *trade winds* passes into that of the *calms.*

132. The *typhoons* of the China Sea owe their origin and direction to causes similar to those which operate in producing the hurricanes of the West Indies.

133. It has been established by Dove and Reid that in all or most great storms the wind has a *rotatory* movement.

134. The diameter of the circle within which the gyration is performed is sometimes equal in extent to several hundred miles.

135. The onward march is at the rate of from forty to forty-eight miles per hour, and the velocity of the whirling motion nearly double.

136. It has been calculated that this velocity of the atmosphere exerts a pressure of thirty-two pounds on the square foot. Mr. Smeaton, however, calculates the pressure at 49·2 pounds, and the velocity at 146·7 feet per second, or at 100 miles per hour.

137. In Western Europe storms generally come from the south-west, and arise from the struggle of a powerful south-west current with one blowing from the north-east.

138. In the temperate zones the wind runs round the compass in one direction. In the northern hemisphere the direc-

tion of this veering is generally contrary to that which prevails in the southern hemisphere.

139. In the temperate regions of the earth, the winds obey no certain laws. The same causes, however, are constantly operating in different forms and degrees, so as to produce all the infinite variety among the winds which we observe in nature.

140. During a period of ten years, from 1807 to 1816, the annual average *proportion* of winds in this country were from—

N. to E.	not including	the latter point	74·4 days.
E. to S.	„	„	53.9 „
S. to W.	„	„	104·4 „
W. to N.	„	„	100·4 „
Variable	„	„	32·4 „
			365·5

141. If two great divisions of the whole be made in the direction of the earth's axis, allotting the variable to each in due proportion, we shall have—

Easterly winds	140	365
Westerly	225	

If in the direction of the equator—

Northerly winds	192	365
Southerly	173	

Thus, a westerly direction is found to preponderate by about a *third* over the easterly, and a northerly direction by about a *ninth* over the southerly, in the winds of these ten years.

138. Buff, op. cit. p. 226.
Phil. Trans. 1757.

140. The Climate of London, by Luke Howard, Gent. London, 1833, 2nd edit. vol. i. p. 75.

142. Mr. Hingeston suggests that the causes of the violence of the winds, if not their directions, are electro-magnetic, and that the partial rarefaction of the air by heat, and its condensation by cold, hitherto employed for explaining the force and current of the winds, are most likely only striking parts of terrestrial electro-magnetism.

Of the Aqueous Vapour of the Atmosphere.

143. Dr. Dalton has shown that the actual quantity of vapour which can exist in any given space depends entirely upon *temperature;* and that the amount of aqueous vapour contained in the atmosphere *increases with the temperature,* and varies with the hour, season, latitude, and height above the sea level.

Dr. Thomson says that 94450 cubic miles of water circulate annually through the atmosphere.

144. Temperature, atmospheric pressure, and quarter of the wind, are all most intimately connected with the vivifying moisture of the air; and, this *quality,* with the manner, frequency, and nature of the precipitation, whether as dew, fog, rain, or snow.

145. The temperature of the atmosphere, everywhere incumbent on the earth's surface, must always be above the point of saturation or "*dew point.*"

Could the contrary obtain, we should be always enveloped in a mist, or overshadowed by clouds, through which the rays of the sun could never penetrate.

146. At the equator, where the mean temperature at the level of the sea is not less than 81°, the mean point of saturation will be 61°. In London, where the mean annual tem-

142. The Atmosphere in relation to Disease, Journal of Public Health, Dec. 1855.

144. Kosmos, vol. i. p. 364.

145. Prout, op. cit. p. 296.

146. Ibid. op. cit. p. 300.

perature is about 49·5°, the mean point of saturation has been fixed by Mr. Daniell at 44·5°.

147. The *dryness* of air is *doubled* at *every increase* of temperature corresponding to 27° of Fahrenheit's scale, and in proportion for all intermediate temperatures. Thus, at the freezing point, air is capable of holding the hundred and sixtieth part of its weight of moisture; at 59° the eightieth part; at 86° the fortieth part; at 113° the twentieth part; and at 140° the tenth part. Whilst the temperature, therefore, advances uniformly in arithmetical progression, the dissolving power which this communicates to the air mounts with the accelerating rapidity of a geometrical series.

148. Hence it follows that, whatever be the actual condition of a mass of air, there must always exist *some temperature* at which it will become *perfectly damp*, and *another* at which it will begin to deposit its combined moisture. Thus air, at the temperature of 86° in a state of absolute saturation, would, if cooled to 59°, part with the fortieth part of its weight in the form of rain.

149. The dryness of the air is, under all circumstances, precisely indicated by the depression of temperature produced on a humid surface which has been freely exposed to its action.

150. *Dew* is occasioned by the earth radiating after sunset a portion of its superfluous temperature into the surrounding space; the air immediately in contact with the surface becomes *cooled below the point of saturation*, and *deposits* a *portion* of its *water* in the form of dew.

151. The deposition of dew is always most abundant during

147. Leslie, op. cit. pp. 123, 42.

149. Leslie, op. cit. pp. 42, 123.

150. Prout, op. cit. p. 310.

151. Ibid. p. 310. Appendix, 570. Buff, op. cit. p. 249.
An Essay on Dew, by William Charles Wells, M.D. London, 1818.
Aristotle, Meteor. Lib. i. C. x.
Plutarch, De primo frigido.
Jefferson, Notes on Virginia, p. 132.

calm and *starry* nights, and in situations freely exposed to the atmosphere, because radiation and cooling take place then more quickly than when the sky is clouded.

On *cloudy* nights dew is never observed on plants elevated a few feet from the ground.

152. Dew is deposited much less copiously on hills than upon plains, in consequence of the cooling of the atmosphere being much more considerable on the latter than on the former.

153. In *every clear* and *calm night* the temperature of the atmosphere *increases* with the distance from the earth to the height of at least 220 feet. Mr. Six, of Canterbury, has shown that the atmosphere at the height of 220 feet, on such nights, is 10° warmer than the stratum only seven feet from the ground (91).

In *still* and *serene* weather the temperature of the air, a *few feet* above the earth, will sometimes *decrease*, even in this country, 18 or 20 degrees between sunset and sunrise, though no change of wind has in the mean time occurred.

154. Dew possesses powerful bleaching qualities, dependent, Dr. Prout believes, on the combination of oxygen with water (*ozone*) (331).

155. *Dew point.* Dew point is that point at which the aqueous vapour of the atmosphere becomes condensed and deposited in minute drops on any substance or surface, the temperature of which has been cooled down below the point of "maximum density" of watery vapour.

Or, in other words, the dew point is that temperature to which the existing state of the atmosphere must be cooled before rain descend.

156. The dew or vapour point is readily found by means of Mason's hygrometer, an instrument which shows at a glance the relative dryness and moisture of the atmosphere by the

153. Pictet, Essai sur le Feu, c. x.
Six, Phil. Trans. 1784, 1788.
Wells, op. cit. p. 219.

degree of cold produced by evaporation from a given surface. It consists of two delicate thermometers of as nearly equal sizes as possible, of which the bulb of one is covered with thin muslin or silk, which is kept constantly moist by the capillary attraction of a few threads of floss silk from a fountain of water attached to it. The descent of the mercury in this thermometer marks the diminution of temperature caused by evaporation from the surface of its wetted bulb. This depression is directly as the rapidity or amount of evaporation: and this again depends upon the state of the atmosphere as to moisture. If this be saturated with vapour, no evaporation will take place from the wetted bulb, and the mercury will remain stationary. If, on the contrary, the air be dry, it will abstract vapour from the moistened bulb, and occasion a corresponding degree of cold, which will be indicated by the fall of the mercury, as compared with the dry thermometer.

157. In order to ascertain the dew point, multiply the difference between the temperatures indicated by the dry and wet bulb thermometers, by the factor in the annexed table, corresponding to the temperature of the atmosphere as shown by the dry-bulb thermometer, from which the product, which is "the *depression of the dew point*," is to be subtracted. The remainder will be the temperature of the "*dew point*."

Thus, if the temperature of the air be 62°, of the wet bulb 54° = 8 × 1·8, the factor, = 14·4°, the "*depression of the dew point*," which, subtracted from 62°, gives 47·6°, the temperature of the *dew point*.

At the temperature of 62° Fah. the elastic force of vapour in the atmosphere supports, according to Dalton, 0·560 in., and by the formula, 0·68 in. of the barometric column, but at 47·6°, by Dalton's table, 0·346 in., and by the formula, 0·41 in. only. One cubic foot of vapour at 62° Fah. weighs, according to Gay Lussac, 6·25 grs., but at 47·6°, 3.95 grs. only. It therefore results that the elastic force of the atmo-

sphere at 62° Fah. must be increased, according to Dalton, by 0·214 in., and by the formula, by 0·270 in., and the weight of a cubic foot of vapour, at the same temperature, by 2·30 grs., before the atmosphere would deposit moisture.

158. TABLE of factors for deducing the dew point from the temperature of the atmosphere and of evaporation, taken from the "Greenwich Magnetical and Meteorological Observations, 1844," and from calculations made by Mr. Glaisher and by Dr. Apjohn:—

Temperature of Atmoshere as indicated by the Dry Bulb Thermometer.	Mr. Glaisher.	Greenwich Magnetical and Meteorological Observations.	Dr. Apjohn.	Temperature of Atmosphere as indicated by the Dry Bulb Thermometer.	Mr. Glaisher.	Greenwich Magnetical and Meteorological Observations.	Dr. Apjohn.
25°	6·5			46 to 48°	2·1	2·2	2·0
26	6·1			49	2·1	2·2	1·9
27	5·6			50	2·1	2·1	1·9
28	5·1	5·7		51	2·0	2·1	1·9
29	4·6	5·0		52, 53	2·0	2·1	1·8
30	4·2	4·6		54	2·0	2·1	1·7
31	3·7	3·6		55	2·0	1·9	1·7
32	3·3	3·1		56 to 58	1·9	1·9	1·7
33	3·0	2·8		59	1·9	1·9	1·6
34	2·8	2·6	2·6	60 to 62	1·9	1·8	1·6
35	2·6	2·4	2·6	63	1·9	1·8	1·5
36	2·5	2·4	2·5	64 to 69	1·8	1·8	1·5
37, 38	2·4	2·4	2·4	70 to 72	1·8	1·7	1·5
39	2·3	2·4	2·3	73 to 79	1·7	1·7	1·4
40	2·3	2·3	2·3	80	1·7	1·6	1·4
41	2·3	2·3	2·2	81 to 84	1·7	1·6	
42	2·2	2·3	2·2	85, 86	1·7	1·5	
43, 44	2·2	2·3	2·1	87 to 90	1·6	1·5	
45	2·2	2·2	2·1	90 to 100	1·6		

159. Dr. Apjohn's *formula* for deducing the dew point from the reading of the wet and dry bulb thermometers, which has long received the general assent of the scientific world, has been superseded by that of M. Regnault, who has recently investigated with much labour and unprecedented accuracy, the entire habitudes of vapours.

159. Cyclopædia of the Physical Sciences, by J. P. Nichol, LL.D. London and Glasgow, 1857. Article "Hygrometer," p. 380.

Dr. Apjohn's Formula.

Let f = tension of aqueous vapour at the dew-point temperature which we desire to know,

f' = the tension of vapour at the temperature of evaporation, as shown by the wet bulb thermometer,

a = the specific heat of air,

e = the latent heat of aqueous vapour,

$(t - t')$, or d = the difference between the reading of the dry bulb thermometer and that of the wet,

p = the pressure of the air in inches;

then $$f = f' - \frac{48a\,(t - t')}{e} \times \frac{p - f'}{30};$$

or, with the co-efficient,

$$f = f' - 01147\,(t - t') \times \frac{p - f'}{30}.$$

160. M. Regnault's Formula.

$$n = f' - \frac{0{\cdot}429\,(t - t')}{610 - t'} \,.\, h.$$

Where n is the elastic force of the vapour actually in the air; t the temperature of the air; and t' that of evaporation in centigrade degrees.

This formula will apply in all cases where the wind is not very strong.

161. The elastic force or tension of the aqueous vapour of the atmosphere supports a certain portion of the barometric column.

160. Ibid.

Mémoires de l'Académie des Sciences, 1847.

Comptes Rendus, 1854.

Edinburgh Philosophical Journal, July 1849.

Philosophical Magazine, Dec. 1854.

Transactions of the Royal Irish Academy, vol. xvii.

The amount of this force at every temperature, from 0° upwards, was ascertained and determined by Dr. Dalton, from numerous and varied experiments, frequently repeated and carefully conducted.

162. The results of Dr. Dalton's observations are found to coincide very closely with the amount of elastic force and pressure of steam deduced from the following formulæ, founded on the hypothesis "that the elastic force of steam increases in equal proportions, from equal increments of temperature, reckoned in true intervals from the bottom of the scale:"—

"Below 212°, or one atmosphere—

$$\left.\begin{array}{l} \text{Log. F} = 7{\cdot}71307\ (\text{log. } t - 2{\cdot}587711) \\ \text{Log. } t = 0{\cdot}12965 \text{ log. F} + 2{\cdot}587711 \\ \text{Where } t = t \text{ Fah.} + 175^\circ \\ \qquad \text{F} = \text{pressure in dec. parts of an atmosphere.} \end{array}\right\} (a).$$

"Above 212°, or one atmosphere—

$$\left.\begin{array}{l} \text{Log. F} = 6{\cdot}42\ (\text{log. } t - 2{\cdot}5224442) \\ \text{Log. } t = 0{\cdot}1557634 \text{ log. F} + 52244422. \\ \text{Where } t = t \text{ Fah.} + 121^\circ \end{array}\right\} (b).$$

"To find the pressure corresponding to any given temperature of steam below 212°:—

"To the temperature add 175°; find the logarithm of that sum; subtract from this logarithm the number 2·587711, and multiply the remainder by 7·71307; the product is the logarithm of the *pressure* in decimal parts of an atmosphere, which, if multiplied by 15, will give *pounds on the square inch*, and, if by 30, *inches of mercury*."

163. The following TABLE shows the elastic force of the vapour of water, in inches of mercury, as determined by Dr. Dalton, and as calculated by the above formulæ (*a*), below 212°; and also the weight, in grains troy, of a cubic foot of vapour, as ascertained by Gay Lussac . . . .

162. Encyclopædia Britannica, article "Steam," p. 597.

Temperature, Fahrenheit.	Elastic Force of Aqueous Vapour in Inches of Mercury. Dalton.	Formula.	Weight in Grains Troy of a Cubic Foot of Vapour at the Sea Level.	Temperature, Fahrenheit.	Elastic Force of Aqueous Vapour in Inches of Mercury. Dalton.	Formula.	Weight in Grains Troy of a Cubic Foot of Vapour at the Sea Level.
0°	0·061	0·07	0·78	61°	0·542	0·66	6·06
5	0·074		0·93	62	0·560	0·68	6·25
10	0·089	0·10	1·11	63	0·578	0·70	6·45
12	0·096		1·19	64	0·597	0·72	6·65
14	0·104		1·28	65	0·616	0·74	6·87
15	0·108		1·32	66	0·635	0·77	7·08
16	0·112		1·37	67	0·655	0·80	7·30
17	0·116		1·41	68	0·676	0·82	7·53
18	0·120		1·47	69	0·698	0·85	7·76
19	0·125		1·52	70	0·721	0·88	8·00
20	0·129	0·15	1·58	71	0·745	0·91	8·25
21	0·134		1·63	72	0·770	0·94	8·50
22	0·139		1·69	73	0·796	0·97	8·76
23	0·144		1·75	74	0·823	1·00	9·04
24	0·150		1·81	75	0·851	1·03	9·31
25	0·155		1·87	76	0·880	1·06	9·60
26	0·161		1·93	77	0·910	1·09	9·89
27	0·167		2·00	78	0·940	1·12	10·19
28	0·173		2·07	79	0·971	1·16	10·50
29	0·179		2·14	80	1·00	1·20	10·81
30	0·186	0·22	2·21	81	1·04	1·24	11·11
31	0·192	0·23	2·29	82	1·07	1·28	11·47
32	0·200	0·24	2·37	83	1·10	1·31	11·82
33	0·207	0·25	2·45	84	1·14	1·36	12·17
34	0·214	0·26	2·53	85	1·17	1·39	12·53
35	0·221	0·27	2·62	86	1·21	1·44	12·91
36	0·229	0·28	2·71	87	1·24	1·47	13·29
37	0·237	0·29	2·80	88	1·28	1·51	13·68
38	0·245	0·30	2·89	89	1·32	1·56	14·08
39	0·254	0·31	2·99	90	1·36	1·61	14·50
40	0·263	0·32	3·09	91	1·40	1·65	
41	0·273	0·33	3·19	92	1·44	1·69	
42	0·283	0·34	3·30	93	1·48	1·74	
43	0·294	0·35	3·41	94	1·53	1·79	
44	0·305	0·37	3·52	95	1·58	1·84	
45	0·316	0·38	3·64	96	1·63	1·89	
46	0·328	0·39	3·76	97	1·68	1·96	
47	0·339	0·40	3·88	98	1·74	2·01	
48	0·351	0·42	4·01	99	1·80	2·08	
49	0·363	0·43	4·14	100	1·86	2·15	
50	0·375	0·45	4·28	105	2·18	2·48	
51	0·388	0·47	4·42	110	2·53	2·83	
52	0·401	0·49	4·56	115	2·92	3·25	
53	0·415	0·51	4·71	120	3·33	3·69	
54	0·429	0·53	4·86	125	3·79	4·19	
55	0·443	0·55	5·02	130	4·34	4·78	
56	0·458	0·57	5·18	135	5·00	5·41	
57	0·474	0·59	5·34	140	5·74	6·13	
58	0·490	0·61	5·51	145	6·53	6·92	
59	0·507	0·62	5·69	150	7·42	7·80	
60	0·524	0·64	5·87	155	8·40	8·79	

Temperature, Fahrenheit.	Elastic Force of Aqueous Vapour in Inches of Mercury.		Weight in Grains Troy of a Cubic Foot of Vapour at the Sea Level.	Temperature, Fahrenheit.	Elastic Force of Aqueous Vapour in Inches of Mercury.		Weight in Grains Troy of a Cubic Foot of Vapour at the Sea Level.
	Dalton.	Formula.			Dalton.	Formula.	
160°	9·46	9·84		190°	19·00	19·00	
165	10·68	11·01		195	21·22	21·19	
170	12·13	12·36		200	23·64	23·52	
175	13·62	13·86		205	26·13	26·05	
180	15·15	15·41		210	28·84	28·83	
185	17·00	17·10		212	30·00	30·00	

164. The force of steam produced in a close boiler by water at 212° Fah., the barometer standing at 30 inches, is an *exact balance* to the pressure exercised by the atmosphere on each square inch of the outside of the boiler, about 15 lbs., and is termed "*steam of one atmosphere.*" If the force of the steam be doubled (245°), or tripled (268°), it is designated steam of *two* or *three* atmospheres, and so on.

165. A cubic foot of vapour at 212°, under a pressure of 30 inches, weighs 258·4 grains. Air expands $\frac{1}{491\cdot13}$ or 0·0020361 for every increase of 1° of Fahrenheit's scale. From 32° to 212°, it therefore expands 0·3665 of its bulk; between these points its expansion is uniform.

The weight of a cubic foot of vapour at any other temperature, under the same pressure, may be calculated from the following formula :—

$$\frac{1\cdot3665 \times 258\cdot4 \text{ gr.} \times \text{elastic force of vapour at temperature}}{30\,(1 + 0\cdot0020361 \times \overline{t - 32^\circ})}.$$

166. *Hoar frost* is frozen dew.

In clear and still nights, frosts are less severe upon hills than in the neighbouring plains (152).

165. Glaisher's Meteorology, p. 35.
166. Theophrastus, lib. v. c. xx.
Wells, op. cit. p. 215.

167. *Mists*, like dew, are the result of the cooling by radiation of the lower strata of the atmosphere. They originate in the vapours which arise from water, and from the surface of the earth.

168. *Fogs.*—The formation of fogs differs from that of dew, in that they usually arise from the influence which air cooled by radiation exerts on warmer air; or, in other words, from the intermixture of air of different temperatures. The surface of lakes, ponds, and rivers, are frequently, in calm weather, covered with fog in the early morning, in consequence of the temperature of the water during the night being above that of the superincumbent air. This latter, becoming warmed by the water, rises surcharged with moisture, which it precipitates in the form of fog upon coming in contact with the cooler air above.

169. It has been affirmed by M. de Saussure, that *mists* and *fogs* (*nuages*) consist of minute hollow spheres or vesicles of water filled with air, having the quality of mutual repulsion. The movements of these vesicles are exceedingly rapid and fantastic ; they chase, fly to, and repel each other in the most grotesque (*bizarre*) and amusing manner.

170. Their formation and suspension in the air are, indisputably, entirely due to the electricity which they derive from the upper strata of the atmosphere.

171. Mountain fogs are produced by the cold of the sides or summit of the mountain condensing the vapour, which a wind hotter than the mountain itself holds in solution. The molecules of water are precipitated, and take the vesicular form.

172. M. de Saussure describes the vesicles of an Alpine fog to have been larger than the largest peas, and inconceivably thin.

173. Fogs are often called *vesicular vapour.*

168. Prout, op. cit. p. 316.

169. Voyage dans les Alpes, tom. iv. p. 281, § 2070.

171. Ibid.

174. "It is probable," says Mr. Glaisher, "that fogs, mist, and haze represent, not mere clouds of aqueous vapour, but other products of terrestrial exhalation, delayed in their transit to space and withheld from the diffusion they had commenced."

175. Great fogs seldom occur unless the barometer be high.

176. *Clouds.*—Clouds are visible collections of minute globules of water suspended in the atmosphere; or, masses of visible vapour, precisely similar to that composing fogs, but elevated to a considerable height above the earth's surface.

177. The formation of clouds depends altogether on *convection,* and is the result of an intermixture, in the higher regions of the atmosphere, of strata of air of different temperatures, and in different states of saturation.

178. *Clouds, forms,* and *modifications* of. Endless as are the forms of clouds, Howard has classed them under "three simple and distinct, and four intermediate and compound, modifications."

The simple modifications are thus named and defined:

(1.) CIRRUS. *Def. Nubes cirrata, tenuissima, quæ undique crescat.*

Parallel, flexuous, or diverging fibres, extensible by increase in any or in all directions.

(2.) CUMULUS. *Def. Nubes cumulata, densa, sursum crescens.*

Convex or conical heaps, increasing upward from a horizontal base.

(3.) STRATUS. *Def. Nubes strata, aquæ modo expansa, deorsum crescens.*

A widely extended, continuous, horizontal sheet, increasing from below upward.

177. Prout, op. cit. p. 316.

178. On the Modifications of Clouds, and on the Principles of their Production, Suspension, and Destruction; being the substance of an Essay read before the Askesian Society, in the Session 1802-3, by Luke Howard, gent. Climate of London, vol. i. Introduction, p. xli. et seq.

The intermediate modifications which require to be noticed are:—

(4.) CIRRO-CUMULUS. *Def. Nubeculæ densiores, subrotundæ, et quasi in agmine appositæ.*

Small, well-defined roundish masses, in close horizontal arrangement or contact.

(5). CIRRO-STRATUS. *Def. Nubes extenuata, subconcava, vel undulata. Nubeculæ hujusmodi appositæ.*

Horizontal or slightly-inclined masses attenuated towards a part or the whole of their circumference, bent downward or undulated; separate, or in groups consisting of small clouds having these characters.

The compound modifications are:—

(6). CUMULO-STRATUS. *Def. Nubes densa, basem planam undique supercrescens, vel cujus moles longinqua videtur, partim plana, partim cumulata.*

The cirro-stratus blended with the cumulus, and either appearing intermixed with the heaps of the latter, *or superadding a wide-spread structure to its base.*

(7). CUMULO-CIRRO-STRATUS *vel* NIMBUS. *Def. Nubes vel nubium congeries* (superné cirrata) *pluviam effundens.*

The rain cloud. A cloud, or system of clouds, from which rain is falling. It is a horizontal sheet, above which the cirrus spreads, while the cumulus enters it laterally and from beneath.

The Clouds as indications of the Weather.

179. The *cirrus* has the *least density*, and the *greatest elevation.* It has long been deemed a prognostic of wind, and is vulgarly called "mares' tails."

180. The *cumulus* is of the *most dense* structure, and moves with the current which is next the earth. It may be considered as the cloud of *day.*

181. The *stratus,* which has a *mean degree* of density, is the *lowest* of clouds, its inferior surface resting on the earth or

water. This is properly the cloud of *night*, forming at sun-set, and disappearing at sun-rise.

182. The *cirro-cumulus* is most frequent in *summer*, and in warm and dry weather.

183. The *cirro-stratus* is almost always followed by a depression of temperature, by *wind* and *rain;* and is the modification which most frequently and completely exhibits the phænomena of the solar and lunar halo, of parhelia, mock suns, and paraselenæ, mock moons.

184. The *distinct cumulo-stratus* indicates the approach of thunder storms; the *indistinct* is chiefly observed in the intervals of showers, rain, snow, or hail.

185. The *cumulo-cirro-stratus* or *nimbus* is peculiarly the *rain-cloud.*

186. Red clouds in the west, with a tinge of purple, portend fair weather, because the air when dry refracts more of the red and heat-making rays than when moist; and, as dry air is not perfectly transparent, those rays are reflected in the horizon.

187. A coppery or yellow sun-set foretels rain.

188. *Clouds, uses of.*—Clouds constitute a sort of intermediate state of existence between vapour and water, by which sudden depositions of water and their consequences are entirely prevented.

189. By means of clouds the waters of seas and oceans are transported by the winds, and deposited far inland, where water otherwise would never reach.

190. Clouds mitigate the extremes of temperature, shielding vegetation by day from the scorching influence of the sun's rays, and by night enabling the earth to retain that heat which would otherwise radiate into space, and cause deposition of dew.

191. Mr. J. A. Hingeston suggests that clouds are more or less analogous to Leyden jars, and that their *several kinds* may serve as indications of the electrical condition of the atmosphere in relation to health and disease.

186. Salmonia, or Days of Fly-Fishing, by Sir Humphry Davy, Bart. LL.D.
188, 189. 190. Prout, op. cit. p. 321. 191. Op. cit.

192. *Clouds, height of.*—The ordinary height of the clouds varies to upwards of a mile, being much more frequently less than more. Dr. Dalton, however, asserts that small fleecy patches of cloud are frequently from three to five miles in height. The boundary beyond which they can seldom rise, says Professor Leslie, is about two miles above the line of perpetual congelation.

193. *Storm clouds* in *mountainous* countries sometimes exceed, says M. Arago, 15,158 feet = 2·87 miles in height (264.)

194. In the temperate zone storm clouds floating over *low lands* have been found on admeasurement to have attained to a vertical height of 25,000 feet = 4·734 miles.

195. During a thunder storm in Paris, 6th June, 1712, De l'Isle ascertained, as the result of four observations, the vertical height of the storm clouds to have been 26,510 feet = 5·02 miles.

196. *Rain.*—It has been shown (13) that the atmosphere contains from one to one and a half per cent. of water in a state of elastic vapour.

197. The precipitation of water from the atmosphere is caused by the cooling, *below the point of saturation*, of a portion of air *saturated* with vapour at any given temperature.

198. *At all temperatures* the existence of *atmospheric air* is *permanent;* the very *existenee*, however, of *vapour* is dependent on *temperature.* If, then, two currents of air, having different temperatures, each saturated with that amount of vapour which is proper to its own temperature, be mingled together, the resulting *temperature* of the mixture will be the mean of the two, though the resulting *tension of vapour* will not be the mean, but will *exceed* that proper to the resulting mean tem-

192. Op. cit. p. 136.
193. Op. cit.
194. Kosmos, vol. i. p. 369.
Arago.
196. Prout, op. cit. p. 325.
198. Leslie, op. cit. pp. 126, 127.

perature; the consequence of this will be an *excess of vapour*, which will be separated, and will assume the form of mists or clouds, or be precipitated as rain, snow, or hail, according to the temperature of the atmosphere. If this be *above* 32° Fahr. the vapour separated will fall to the earth in the state of rain; if below 32°, of sleet, snow, or hail.

For instance, if equal bulks of air, in a state of saturation, the one at 59°, the other at 113°, be intermingled, the resulting compound will have a mean temperature of 86°. But, as the elastic force of vapour at 59° is ·507 inch, it follows that air at that temperature would suspend about the eightieth part of its weight of vapour; and at 113° it would suspend the twentieth part of its weight, the elastic tension of vapour at that temperature being 2·75 inches. The mean temperature of the two would be 86°, and the mean of their elasticities 1·6285 inches. As however air at 86° can only suspend the fortieth part of its weight, its tension being 1·21 inch only, the difference, ·4185 inch, amounting to a hundred and sixtieth of the whole weight of the air, must be precipitated from the compound mass.

199. If, in its descent, the separated moisture pass through a stratum of air warmer than the mean of the two from which it had been precipitated, it may be suspended in this warmer current, and may not reach the ground. If the converse obtain, the drops of rain would, in their passage through a colder stratum of air, increase in size during their descent to the earth.

200. Rain drops vary from the thirtieth to one third of an inch in diameter.

201. One cubic inch of rain weighs 252·525 grains.

202. Some few instances are recorded of "luminous rain," that is, drops of rain emitting light on reaching the ground or striking against any other object, or even against each other.

202. Arago, op. cit. pp. 106, 107.

203. More rain falls in the neighbourhood of the sea than *at* sea.

204. More rain falls among mountains than on plains.

205. In most *tropical* countries rain falls only at particular seasons of the year, and is the result of the change in the direction of the trade winds.

206. In *temperate* climates more rain falls during the latter half than during the first half of the year.

207. *Moon, influence of phases of, in the production of rain.*—Though it cannot be denied that there does exist some correspondence between the fall of rain and the phases of the moon, yet the popular notions concerning the influence of these on the former have no foundation in theory, and no correspondence with observed facts. If any influence, how feeble soever, be exerted by the moon, it is dependent on her relative position to the sun, and not on her power of attraction.

208. *Snow.*—Snow is the frozen visible vapour composing clouds; and affords the simplest illustration of the precipitation of water from the atmosphere. If the quantity separated be small, the frozen particles of water remain detached, and float in the atmosphere in the form of crystallized spiculæ; but if the quantity of water separated be large, the crystallized particles are agglutinated together into masses or flakes, and fall to the earth in the form of snow.

209. Snow crystals possess an infinite variety of form, and a singular beauty of arrangement. Their figures are compounded of hexagons, and their component parts respectively arranged at an angle of 60°, that at which water crystallizes. In these latitudes the crystals are very minute, and rarely exceed 0·5 inch in diameter.

204. Prout, op. cit. p. 327.
205. Ibid. p. 328.
206. Howard's London, p. 115.
207. Museum of Art and Science, by D. Lardner, vol. i. pp. 79, 80.
208. Prout, op. cit. p. 322.
209. Glaisher, op. cit. p. 52.

210. The crystalization of snow is intimately connected, says Mr. Glaisher, with the electrical and chemical condition of the atmosphere; an opinion in which Dr. Smallwood of Canada and Sir Edward Belcher concur.

211. Snow, by its *low conducting properties* and *lightness*, protects vegetation from the rigorons cold of higher latitudes.

A thick covering of snow, by preventing the radiation or conduction of the heat of the ground to the atmosphere, renders the surface of the former warmer, and the lower stratum of the latter colder, than they would otherwise be.

212. A fall of snow from 8 to 12 inches deep will produce one inch of water.

213. Snow-flakes bring down the ozone from the cirriferous and ozoniferous regions of the atmosphere.

214. *Sleet* is half-melted snow; and is in the intermediate condition between this and rain.

215. *Hail* may be regarded as drops of rain more or less suddenly frozen. The icy nucleus acquires magnitude in its descent, by condensing on its surface the vapour of the lower and colder regions of the atmosphere.

216. Hail-stones sometimes attain to an enormous magnitude, many inches in size, and many pounds in weight. On the 4th May, 1697, hail-stones fell in Hertfordshire 14 inches in circumference; and in 1784 hail-stones are said to have fallen in the Pyrenees weighing 23 ounces each.

217. Whole districts are sometimes devastated by the fury and severity of hail-storms. In 1847 the two small communes

210. Glaisher, op. cit. p. 52.
211. Wells, op. cit. p. 257, 258.
212. Glaisher, op. cit. p. 52.
215. Prout, op. cit. p. 332.
216. Ibid. p. 333.
Howard, op. cit.
Nicholson's Journal, viii. 73.
217. Meteorological Essays, by François Arago, translated under the superintendence of Colonel Sabine, R.A. London, 1855, p. 236.

of Vaux and Arbuissonas, in the vine-districts of Burgundy, lost by hail crops exceeding 60,000*l.* in value.

Hail is necessarily connected with electricity, and is a common attendant of violent thunder-storms.

218. *Amount of evaporation and condensation of water over the globe, and over England and Wales.*—The superficies of the globe consists of 170,981,012 square miles, of which the dry land amounts to 52,745,253. Assuming the mean annual quantity of rain for the whole globe to be 34 inches, the quantity of rain falling annually will amount to somewhat more than 91,751 cubic miles of water, and the quantity falling on the dry land to 30,960 cubic miles.

219. The mean annual evaporation over the whole surface of the globe has been computed by Dr. Thomson and Dr. Dalton at 35 inches, which gives 94,450 cubic miles for the water annually evaporated over the whole globe.

220. Aristotle remarks that, "as the sun is continually evaporating the water of the sea, it must eventually be entirely dried up." We have reason, however, to believe that all the water which is evaporated by the solar heat, or by any other natural process, and rises into the atmosphere, is again, by the operation of certain disturbing causes, precipitated in the form of rain, dew, snow, or hail.

221. Dr. Halley calculated that 5,280 millions of tons of water were evaporated from the surface of the Mediterranean Sea in one summer only.

222. The area of England and Wales has been accurately determined by the trigonometrical survey to consist of 57,960

218. Carr, op. cit. p. 225.

220. Meteor. ii. i.

Leslie, op. cit. p. 37.

222. Local Taxation, with the area of the several counties in England and Wales, ordered by the House of Commons to be printed, 6 December, 1830, p. 7.

The area of an English square mile to the geographical square mile, is, on the authority of General Mudge, as 300 to 398·6; or, in other words, *four* English square miles are equal to *three* geographical square miles.

square statute miles: that of the former being 50,535, and of the latter, 7,425.

223. Assuming the mean annual evaporation to be 36 inches, the annual quantity of rain and dew falling in England and Wales will be 28 cubic miles of water.

224. *Rainbow.*—A circular arch of variously coloured light, visible in the heavens when the sun or moon is shining, and a shower of rain is falling at the same time.

225. The rainbow is produced by the sun's rays falling upon the drops of rain near their upper surfaces, where, being refracted, they pass to the side of the drop which is furthest from the sun and the spectator, whence they are reflected towards the lower surface; and, on quitting the drop, they suffer a second refraction. Each pencil of rays on emerging from the drop consists of parallel rays of light, which produces in the mind of the spectator the perception of brightness. Light is therefore *twice refracted* and *once reflected* within each drop of rain or vesicle of vapour.

226. Descartes was the first who distinctly explained the cause of the production of the rainbow; but it was left for Sir Isaac Newton, after he had discovered the different degrees of refrangibility in the various coloured rays which compose a pencil of white or compounded light, to assign the cause of the coloured bands in the rainbow, the order of their position, and the breadth which they must occupy.

227. As the rainbow can only be seen when the clouds precipitating the rain are opposite the sun, it follows that a *morning* bow, in the south-west, portends, with a south-west wind, the approach of rain, and, with an easterly wind, that it is passing away. An *evening* bow in the east, with a south-west wind, indicates fair weather, and that the rain has passed away; but, with an easterly wind, that it is approaching.

228. The *lunar rainbow* is in general white; but, when

226. Meteor. cap. viii.

227. Salmonia, or Days of Fly-Fishing, by Sir Humphry Davy, Bart. LL.D.

coloured, differs only from that produced by the sun's rays in the colours being much more faint, in consequence of the lesser light of the moon-beams.

229. *Halo,* or *corona.* A white or iridescent luminous circle, or concentric circle, seen occasionally surrounding the sun or moon at some distance from the disc of the luminary.

230. Coloured solar halos may appear at 7° to 10°, at 22° to 30°, and at 46° from the sun: a colourless halo may appear at 90° from the sun.

231. According to Descartes they are caused by the refraction of light in small equilateral prisms of ice which float in the air; and to Dechales, in the aqueous (vesicular?) vapour of the atmosphere, the colours of the rainbow appearing in those drops which are 23 degrees distant from the luminary. M. Mariotte is of opinion that small coronas are formed by the transmission of light through aqueous vapours, in which it suffers two refractions without any intermediate reflection.

232. Descartes observed that halos are never seen when rain is falling.

233. A halo round the moon is a most certain indication of wet weather. The larger the circle the nearer are the rain clouds.

234. *Parhelia* (from παρὰ, by the side of, ἥλιος, the sun), and *Paraselenes* (παρὰ, by the side of, σελήνη, the moon), *mock suns,* and *mock moons,* appearing simultaneously with the luminary, are supposed to be produced by refraction of light in innumerable short equilateral prisms of ice. Both are coloured.

235. Pliny tells us that no account had been handed down of more than *three* mock *suns,* and *three* mock *moons,* having been seen.

> Plures, simul, quàm tres, visi, ad hoc ævi nunquam produntur.
> Lunæ quoque trinæ apparuere.

231. Aristotle, Meteor. lib. iii. cap. ii. p. 575.
233. Ibid.
235. Hist. Nat. lib. xxxi. xxxii.

The death of Prince Arthur is said by Shakspere to have been followed by the appearance of *five* mock *moons*.

> *Hubert.* My Lord, they say, five moons were seen to-night:
> Four fixed; and the fifth did whirl about
> The other four, in wond'rous motion.

Edward the Fourth, during the battle of Mortimer's Cross, near Hereford, Feb. 2nd, 1461, saw three suns, which he interpreted as an omen of his own success, and of the final discomfiture of the house of Lancaster. They were interpreted to typify the three crowns of England, France, and Ireland. Edward subsequently adopted the rose in a sun as his badge.

Mr. Huygens saw *five suns* at Warsaw in 1658.

236. *Anthelia* (from ἀντι, opposed to, ἥλιος, the sun), *false suns*, appear on the side of the heavens opposite to the true sun, and are supposed to be produced by two refractions, and two internal reflections, in such prisms of ice. In this case the image would be about 83° from the true image of the sun.

237. Mr. Howard, on the 15th July, 1829, saw *five* false suns.

238. *Mirage.*—A French term expressive of an *optical illusion*, occasioned by the unusual refraction of light through contiguous masses of air of different densities and temperatures, by which distant objects on the land or water appear to be reflected and inverted.

Electricity and Magnetism of the Earth.

239. The diurnal rotation of the earth, on its axis from west to east, occasions, in the equatorial regions, constant and successive unequal heating and cooling of its surface in the contrary direction from east to west. Currents of *thermo-*

235. Sandford's Genealogical History.
236. King John, act IV. scene ii.
237. Op. cit. vol. iii. p. 326.
239. Prout, op. cit. p. 241.

electricity are thereby established in the latter direction. These give rise to the *magnetism* of the earth, the directive power of which is of necessity *at right angles* with the former.

240. The earth may therefore be viewed, first, as one huge *electrical machine*, of which the direction of the currents is from *east* to *west;* and, secondly, as a *vast magnet*, of which the poles are beneath the surface, and of which the directive force is nearly parallel with its axis, or from *north* to *south*.

241. *Electricity of the atmosphere.*—The atmosphere abounds with electricity, which it derives from the thermo-electric agency of the earth.

242. Electricity, from the universality of its action, doubtless plays an all-important part in the sustentation of health, the germination of plants, the production of ozone, the formation of clouds and rain, snow and hail, in the thunder-storm, the tempest, and the whirlwind.

243. The sources of electricity in the atmosphere are to be found in the chemical changes which often accompany the evaporation of water and the respiration of plants, and in combustion.

244. Dr. Prout is of opinion that one source of electricity of the atmosphere is derived from a combination of water and oxygen, a compound analogous to the *deutoxide of hydrogen* (ozone), which he supposes to be a frequent, if not a constant, ingredient in the atmosphere, and the cause of numerous atmospheric phenomena which are at present but little understood.

245. The electricity of the air increases continually in proportion as we get further from the surface of the earth; but at a certain height it becomes uniformly constant.

246. The effects of electricity are much more striking, as connected with the water in the atmosphere, than with the constituents of the atmosphere itself.

244. Bridgewater Treatise, p. 342, and Appendix, p. 569.

245. De Saussure, op. cit. tom. ii. p. 413, § 1035.

247. *Dry* and pure air is one of the most complete non-conductors of electricity.

248. In clear, calm, and unclouded weather, the electricity is generally of the *positive* kind, but upon the first appearance of rain, snow, or hail, it usually changes to *negative.*

That of the *earth* is invariably *negative.*

249. The usual positive electricity is weakest during the night, and at its minimum at 3 A.M.; it increases with sun-rise, decreases about noon, increases again towards sun-set, and diminishes and remains feeble during the night.

250. The atmosphere is *least electrical* during the prevalence of N.N.W. and N. winds, and N.N.E. and N.E. winds; and *most electrical* when the wind blows from E.S.E. to S.E., and from W.N.W. to N.W., facts which have been recorded by M. Quételet, Astronomer Royal of Belgium.

251. The same learned professor, in a communication to the Société Royale de Belge, 8 Sept. 1849, stated, that atmospheric electricity is in its highest intensity during the month of January, and attains to its minimum in June. The value of the months is in the relation of 32 to 1 when the sky is perfectly serene, and of 8 to 1 when it is clouded.

252. The distribution of electricity decreases from the equator to the poles.

253. Electrical phenomena are most energetic and of most frequent occurrence in countries and in seasons in which the solar influence is the greatest.

254. The electrical powers follow the law of gravitation in being *in the inverse ratio of the squares of the distances of the acting bodies.*

255. The prevalence of epidemic or pestilential disease has been associated with the absence or deficiency of *positive* elec-

247. Prout, op. cit. p. 339.
248. Brande, op. cit. p. 189.
249. Ibid. p. 190.
252. Prout, op. cit. p. 340.

tricity in the atmosphere; and the mortality has been found to be in the inverse ratio of the amount of *positive* electricity with which the air is charged.

256. This was especially remarked during the last visitation of the Asiatic cholera.

257. In the "non-electric" states of the air, or when the electricity is "weak" or "nothing," diseases of a low type prevail, and the mortality increases. On the contrary, when the electricity is "positive," strongly positive," and "active throughout the day," the number of deaths decreases.

258. *Thunder and lightning.* The electrical equilibrium of the atmosphere is disturbed by thunder-storms.

259. Lightning is caused by the passage of electricity between one cloud and another, or between a cloud and the earth. Thunder is the noise produced by such passage.

260. In England, France, and Germany, the mean annual number of days of thunder and lightning rarely amounts to twenty. At Rio Janeiro, and at places in India, it is above fifty. In the equatorial regions on all days of the year, and at all hours of the day, electrical discharges are continually taking place in the atmosphere.

261. In Norway it rarely thunders: in Iceland, once only in two years: in Peru, never.

262. Above the 70° N. lat. we are beyond the regions of thunder-storms.

263. Lightning is of three kinds, *zig-zag* or *forked; sheet* lightning, which illuminates whole clouds, and that in the form of *fire-balls*. The duration of the two first is scarcely $\frac{1}{1000}$ part of a second; of the globular kind several seconds.

255. Glaisher, Meteorology of London.
257. Hingeston, op. cit.
259. Glaisher, op. cit. p. 45.
260. Arago, op. cit. p. 111.
Boussingault.
261, 262, 263. Kosmos.

264. The *vertical height* of storm-clouds varies considerably (193). The greatest elevation, with one exception, which has been recorded is 26,510 ft. = 5·02 miles.

265. At the temperature of 62° Fah. the velocity of sound has been determined by Sir John Herschel to be 1125 feet per second = 12·784 miles per minute. Every increase or decrease of temperature of 1° of Fahrenheit's scale occasions a corresponding increase or decrease of 1·14 foot per second in the velocity of sound. At 32° Fah. sound travels at the rate of 1090·8 feet per second.

266. De l'Isle once counted 72 seconds between the lightning and the thunder. Assuming the temperature of the air to have been only 45° Fah., the velocity of sound would be 1105·62 feet in every second of time. Seventy-two seconds multiplied by 1105·62 feet, gives 14·07 miles as the distance of the cloud in which the lightning appeared.

267. Lightning sometimes destroys altogether the magnetism of the needle of a compass, and occasionally inverts its magnetic poles.

268. Lightning is never more dangerous than in winter.

269. Thunder-storms occur less frequently in winter than in summer, and at sea than on land.

270. Mr. Lewis Weston Dillwyn maintains that thunder-storms are more frequent and severe in limestone countries than others.

271. It is said that lightning never strikes the northern face of buildings; and that the south-east is the aspect most exposed to danger.

264. Arago, op. cit.
265. Encyclopædia Metropolitana, article "Sound."
267. Arago, op. cit. p. 88.
268. Ibid. p. 137.
269. Ibid. p. 126.
270. Howard, op. cit.
271. Arago, p. 198.

272. *Chemical modifications in the atmosphere occasioned by thunder and lightning.*—During thunder-storms the composition of the atmosphere undergoes certain chemical modifications. Lightning, as it darts across the vast extent of the upper regions of the atmosphere, determines the sudden combination of its two gaseous elements, azote and oxygen, transforming them into nitric acid.

273. *Aurora borealis.*—This mysterious luminous apparition, of which the magnetic pole seems to be the focus, usually makes its appearance in the northern quarter of the heavens.

274. It is not a simple phenomenon of light, similar to the rainbow, coronas, parhelia, &c.; but appears to be, and no doubt is, connected with the magneto-electric forces of the earth.

275. Auroras are almost always attended by an irregular deviation of the north end of the horizontal magnetic needle. The perturbations during the same aurora are sometimes to the east, and sometimes to the west.

276. Northern lights, though not visible above the horizon, strongly influence the declination, inclination, and intensity shown by magnetic needles. In the words of Humboldt, "the magnetic tempests announce themselves by the perturbations of the magnetic needle, even when no traces of their luminous manifestation are seen on the celestial vault."

277. During a great aurora seen at Paris, 7th January, 1831, the extent of the diurnal variation of the declination needle rose to 1° 16′ 33″, and that of the inclination needle to 20′.

278. The influence exercised by visible and invisible auroras on the magnetic needle is also felt by the electric telegraph

272. Arago, p. 150.
273, 274. Ibid. p. 389.
275. Ibid. p. 410.
276. Ibid. pp. 426, 500.
277. Ibid. p. 481.

needle. At Florence the magnet was constantly thrown back on the same side, and the apparatus rendered entirely useless for three hours. A similar effect is recorded by Mr. Heighton, telegraphic engineer of the London and North-Western Railway Company.

279. Dr. Dalton computed the vertical height of the arch of an aurora seen 29th March, 1826, to have been 100 miles, its breadth 8 or 9 miles, and its visible extent from east to west upwards of 500 miles.

280. *Heat and Light.*—It is exceedingly probable that heat and light consist of polarized molecules in the self-repulsive state, and that they obey the laws observed by ponderable matters in the gaseous form.

281. Heat is propagated by radiation, conduction, and convection. Light by radiation only.

282. The distribution of heat and light, in their latent and decomposed forms through the atmosphere, decreases from the equator towards the poles.

283. *Light* results from undulatory movements, not of the air, but of a certain extremely rare and highly elastic medium filling the whole universe, and which it has been agreed to call ether.

284. Light uniformly traverses space with a velocity of nearly 200,000 miles in a second of time, or, is an eight-thousandth part of a second in travelling 25 miles. According, however, to the latest researches of Struve, the "propagation of light" is 41,518 geographical = 166,072 English miles in a second; nearly a million times more rapid than the rate of sound.

278. Arago, pp. 498, 499, 500.
279. Ibid. pp. 444, 445.
280. Prout, op. cit. p. 83.
281. Ibid. p. 208.
282. Ibid. p. 339.
283. Arago, p. 147.

Each ray of light consists of three separate rays, a ray of *heat*, a ray of *light*, and a ray of *actinism* (from ἀκτὶν, a ray). Mr. R. Hunt, to whom we are indebted for the discovery of the actinic ray, has shown that this is necessary to germination and vegetation. In spring, during germination, and the budding of trees and plants, the solar beams abound with these rays; in summer, during the formation of the woody portions of plants, the light-giving rays prevail; and in autumn, the calorific, heat-giving, or ripening principle of the solar ray is increased.

Yellow glass is impervious to the actinic ray.

285. It has been calculated that a vertical ray of light in its passage through the clearest air loses at least a fifth part of its intensity before it reaches the earth's surface; and that, of a thousand rays emanating from the sun, only 378, on an average, can penetrate to the surface of the earth at the equator; 228 at the latitude of 45°; and 110 at the poles.

286. Euler has calculated the *light* emitted by the sun to be equal to that of 6560 candles at one foot distance. Leslie considers it 12,000 times more powerful than that of a wax candle; in other words, if a portion of the luminous solar matter rather less than half an inch in diameter, were transferred to our planet, it would throw forth a blaze of light equal to the effect of twelve thousand wax candles.

Humboldt, on the other hand, defines the sun to be a dark, black mass.

It is now generally admitted that the centre of our system is an opaque body surrounded by a luminous envelope. Arago has proved beyond all doubt that the light of the sun emanates, not from an incandescent solid body, but from a gaseous atmosphere; the light of the sun, like that emitted by gaseous

284. Kosmos, vol. i. p. 163.
285. Encyclopaedia Britannica, article "Climate."
286. Young's Nat. Philosophy.
Leslie, op. cit. p. 61.

bodies, being *unpolarised*, whilst that of incandescent solid bodies is polarised.

287. To the *decomposition*, *refraction*, and *reflection* of light by the vapour of the atmosphere, we are indebted for the cærulean tint of the sky, and all the splendid colouring of the clouds, nay, even for the light of day itself.

288. "The primary source of *heat*," says Professor Leslie, "is the sun, whose genial rays are partly detained in the atmosphere, and partly received at the surface of the land and of the ocean."

289. M. Pouillet has estimated the amount of heat annually received by the earth from the sun to be equal to that which would be produced by the combustion of a stratum of coal seventeen miles in thickness, or sufficient to melt a stratum of ice covering its entire surface nearly forty-six feet thick.

290. Light is indispensably necessary to animal and vegetable life. It produces certain special effects on the respiration of both kingdoms. In the absence of light, plants absorb *oxygen*, and give off *carbonic acid*. Animals in the hours of darkness *exspire a smaller amount* of carbonic acid than during the day. This has been, though erroneously, attributed to sleep. The difference is mainly owing to the absence of sunlight. Animals are more speedily fattened in the dark than in open daylight. From a like cause, though differently induced, healthy individuals about and after the middle periods of life become fat and *embonpoint*, in consequence of the *diminished amount of carbonic acid exhaled from the lungs.*

291. Though this matter belongs more properly to the subsequent divisions of our subject, it may not be altogether irrelevant to state that youthful exercise, by quickening the respiration and circulation, occasions a larger demand for food, a greater consumption of carbon by, and an increased exha-

287. Prout, op. cit. p. 343.

288. Op. cit. p. 3.

289. Elémens de Physique expérimentale et de Météorologie, tom. ii. p. 704.

lation of carbonic acid from the lungs; and hence, if the young and active do not grow thin, at least they do not become fat. In advanced life, if the pulse and respiration be slow, the effects of diminished exhalation of carbonic acid are counteracted by a failing appetite. In fever, we see the quickened circulation and respiration, the sustained heat, the increased combustion of carbon, the diminished supply, the increased exhalation of carbonic acid from the lungs, combine to produce wasting and emaciation.

292. Men and vegetables deprived of light become etiolated. Of these we have examples in the colourless state of the *barbe de moine* grown in cellars, and of that portion of our garden celery which has been earthed up in order to exclude light; and of those in the blanched and stunted denizens of cellars, and of alleys, courts, and narrow streets surrounded by lofty buildings, which exclude the cheering and colouring influence of the solar rays.

293. The backs of fish and quadrupeds exposed to the light are highly coloured; their under-surfaces, on the contrary, are pale or white. The plumage of birds, and the colours of the flowers of tropical climes exposed to the full influence of the solar rays, are gorgeous, deep, and brilliant, and as varied as beautiful. In northern climes the opposite obtains.

Earth, Internal Temperature of.

294. In contra-distinction to the "law of decrement of temperature corresponding with the height above the sea-level under different parallels of latitude," is that "of the increment of *temperature* of the *interior of the earth with increasing depths.*"

295. The temperature of the earth increases with the distance from the surface.

296. The temperature of the upper crust of the earth

294. Kosmos, p. 171. 295, 296. Ibid. p. 182.

appears, on an average, to increase 1° of Fahrenheit's scale for every 54·496 feet in perpendicular depth.

297. Did this increase observe an arithmetical progression, a granite stratum at the depth of 5·2 geographical miles would be in a state of fusion.

298. In Europe, between the parallels of 48° and 52°, at a depth of from 55 to 60 feet, a stratum of *invariable temperature* occurs. In tropical climates this is found to be only one foot below the surface.

299. The mean temperature of the earth has not altered by the $\frac{1}{170}$th part of a thermometrical degree since the age of Hipparchus, full 2,000 years ago.

300. *Hot Springs.* The temperature of the waters of a spring will afford a tolerably accurate idea of the depth of its source.

301. The temperature accords with that of the stratum in which they have their origin.

302. Thus, the temperature of the Sprüdel at Carlsbad is 165°, and of the Bath waters 114°. Now, supposing the waters of these springs not to lose any of their temperature in their passage to the surface of the earth, the source of the first will be 54·496 ft. × 165° = 1·703 mile, and of the second 54·496 × 114° = 1·1766 mile, in perpendicular depth.

303. The hottest springs are the purest, and their waters contain the smallest quantity of mineral matter in solution.

304. *Mines, temperature of.* The mean of a series of observations has shown that the increment of temperature in mines varies in different countries, and in different parts of the same country.

305. In the Lancashire mines the increment is 1° for every 51 ft. of perpendicular depth; in those of the north of England 1° for 48 ft.; in Saxony 77 ft.; Britany 47 ft.; Mexico 36 ft.; and in Siberia 30 ft.

297. Kosmos, p. 184. 298. Ibid. p. 185.
299. Ibid. 186.

306. Mr. Hutchinson descended the South Hetton mine, near Newcastle-upon-Tyne, 1,488 feet deep, and found the thermometer rose 10° only. This gives 148·8 feet for each degree.

Of the Chemical Constituents of the Atmosphere.

307. *Oxygen* (from ὀξὺς *acid*, and γεννάω to *generate*). This elementary body was discovered by Priestley in 1774; and was named by him, *dephlogisticated air;* by Scheele, *empyreal air;* and by Condorcet, *vital air.*

308. This gas is insipid, colourless, and inodorous, and is permanently elastic under all known pressures and temperatures. At mean temperature and pressure, one hundred cubic inches weigh 34·38 grains. Its specific gravity, compared with atmospheric air, is as 1·1093 to 1000.

309. Oxygen is a powerful supporter of combustion and respiration. It is more abundantly diffused throughout nature than any of the other elementary bodies. It forms eight-ninths, by weight, of water; about one-fifth of the weight of the atmosphere; and a large relative proportion of the earthy and mineral bodies of which the solid matter of the globe is made up. It also constitutes, with scarcely one exception, an element of the various products of organised bodies, both animal and vegetable.

310. The total weight of the oxygen of the atmosphere is estimated as equal to 134,000 cubes of copper, one kilometre in the side.

311. It is unfit for the continuous support of life. If an animal be made to breathe oxygen for any length of time, it

306. Med. Chir. Trans. vol. xxix. p. 228.
308. Brande, op. cit. p. 272.
309. Dumas, op. cit. p. 19.
310. Vide note 53, p. 15.

falls a sacrifice to excess of arterial action; and, after death, the blood in the veins is found of a florid arterial colour.

312. The importance of oxygen to the animal economy, to the preservation of the health, and to the existence of man and the lower animals, will be shewn in the Chapter on *Respiration.*

313. *Nitrogen* (from *νίτρον*, *nitre*, and *γεννάω*, to *generate*), so called because it is the generator of nitre. Dr. Priestley named it *phlogisticated air.*

314. *Nitrogen* is a permanently elastic gas at all known temperatures and pressures. It has not any colour, taste, or smell. It is, in the strictest sense of the word, a non-supporter of combustion; it extinguishes instantaneously and perfectly a lighted taper when introduced into it. No animal which respires can therefore live in it, whence it was called by Lavoisier *azote* (from *a privative*, and *ζωή*, *life*).

315. One hundred cubic inches weigh, at mean temperature and pressure, 30·15 grains. It is rather lighter than atmospheric air, compared with which its specific gravity is 0·971.

316. Nitrogen, as it exists in the atmosphere, mixed with oxygen, is absolutely essential to animal life, for no other gas can be substituted for it. Its principal office appears to be to dilute the oxygen. Its destructive effects on animal life do not arise from any inherent poisonous or injurious quality, but are altogether dependent on the absence of oxygen.

317. Nitrogen abounds in the animal tissues.

318. *Carbonic acid*, named by Dr. Black *fixed air.*—This gas is colourless, of a slightly sour odour and taste, and is much heavier than atmospheric air, its specific gravity being about 1·523. One hundred cubic inches, at mean temperature and pressure, weigh 47·2 grains. It consists of one atom of carbon $= 6$, and two of oxygen, $= 8 \times 2 = 16 : 22$.

313. Brande, op. cit. pp. 326, 327.

316. Elements of Physiology, by J. Müller, M.D. translated by W. Baly, M.D. London, 1840, 2nd edit. vol. i. p. 310.

318. Brande, op. cit. p. 464.

319. Carbonic acid is perfectly unrespirable, and, when pure, immediately suffocates animals plunged into it, by causing a spasmodic closure of the *rima glottidis*, so as to prevent effectually the smallest portion from entering the lungs.

320. When mixed with more than twice its volume of atmospheric air, it ceases to provoke spasm of the *rima glottidis*, and may be taken into the lungs, in which case it gives rise to symptoms resembling apoplexy, &c.

321. Atmospheric air which contains more than ten per cent. of carbonic acid, is quickly destructive of life.

322. Carbonic acid not only destroys life, by inducing narcotism and fatal stupor, but the múscular fibre of animals killed by it loses its irritability, and is rendered insensible to the stimulus of galvanism.

323. In consequence of its great specific gravity it occupies the lower parts of wells, caverns, and mines. By miners it is called "*choke-damp.*"

324. Ten thousand volumes of atmospheric air contain 4·15 of carbonic acid, or less than ·01 per cent. (12).

325. Carbonic acid is a most abundant natural product. It is poured forth in vast quantities from numerous and extensive air-springs, the last efforts of volcanic activity, in various parts of the old and new world. They are met with in Greece, Germany, and Italy, and have been celebrated by Strabo, Pliny, Virgil, Seneca, Apuleius, and others of the old writers.

326. They are generally, writes Pliny, called vents, or Charon's sewers, or Charonæan caves (spiracula vocant, alii Charoneas scrobes). They exist at Socrate, Sinuessa, and Puteoli; at Amsanctum in the country of the Hirpini, at Mephitis, at Aornos in Epirus, and at Hierapolis in Asia.

326. Caii Plinii Secundi, Historiæ Naturalis, lib. ii. cap. xcv. 93.
Seneca, Nat. Quæst. vi. 28.
Virgil, Æn. vii. 563, et seq.
Apuleius, de Mundo; § 729. Strabo, xii.
Pliny, op. cit. lib. v. cap. i.

327. Carbonic acid is generated by the combustion of any body containing carbon as one of its component parts, such as coal, wood, oil, tallow, &c. and, also, by the respiration of animals. It is emitted in large quantities by bodies in the state of vinous fermentation.

328. Being also a product of respiration, it is largely generated in crowded, illuminated, and ill-ventilated rooms, where it occasions difficulty of breathing, giddiness, and faintness.

329. The best means of resuscitation are free exposure to the open air, cold affusion, dashing the face with cold water, the application to the nostrils of the fumes of aromatic vinegar and spirits of sal volatile or hartshorn, artificial inflation of the lungs with a mixture of oxygen gas and atmospheric air, Dr. Marshall Hall's "ready method," voltaic electricity, moderately stimulating drinks if the patient can swallow, friction of the chest and extremities, stimulating enemata, and the restoration of the natural warmth of the body. Bleeding is useless and next to impossible.

330. Dr. Christison, however, recommends "moderate blood-letting, either from the arm or the head," and quotes a case in which cupping from the nape of the neck was successfully employed when various other remedies had failed.

331. *Ozone* (from ὄζω, to *stink*). This is one of the ingredients of the atmosphere, the discovery of which was claimed in 1848 by Professor Schönbein, of Basle. A reference, however, to pages 342, 343, of Dr. Prout's *Bridgewater Treatise*, published in 1834, and to pages 569, 570, of the *Appendix* to the same, will show that he had already discovered the existence of this compound, which he believed to be "analogous to, not identical with, the deutoxide of hydrogen." Dr. Prout was of opinion, "that the *excess* of oxygen above the amount of 20 per cent. which there ought to be in the atmo-

328. Baly's Müller's Physiology, vol. i. p. 311.

330. A Treatise on Poisons, by Robert Christison, M.D. Edinburgh, 1829, p. 603.

sphere, if its composition were, as there can be little doubt that it is, determined by the laws of chemical proportions," "becomes associated with the vapour of the atmosphere, and forms a *deutoxide of hydrogen?*" "The oxygen and vapour in this combination," says Dr. Prout, "are feebly associated, and appear to be separated by the slightest cause."

332. Ozone is a teroxide of hydrogen, consisting of three atoms of oxygen $= 16 \times 3 = 48$, and one of hydrogen $= 1$.

333. Schönbein believes ozone to be a regular constituent part of free atmospheric air, in appreciable though varying quantity, and to be everywhere incessantly and naturally formed out of atmospheric oxygen, in consequence of electrical discharges constantly taking place in the air.

De la Rive and Berzelius consider ozone to be nothing but allotropised oxygen.

Scoutellen defines ozone to be oxygen positively electrified.

334. "Ozone," says Schönbein, "is the most powerful oxidising agent we yet know of, transforming, in the cold, even silver into the peroxide of that metal, iodine into iodic acid, nitrogen (a strong base being present) into nitric acid, the '-ous' acids into '-ic' acids, the '-ites' salts into '-ates' salts, the metallic sulphurets into sulphates."

335. "Ozone destroys, instantaneously, sulphuretted, seleniuretted, phosphoretted, ioduretted, arseniuretted, and stibiuretted hydrogen, oxidising their constituent parts."

336. Schönbein has demonstrated ozone to be one of the chemical antipodes and antidotes to all oxidable miasmatic and malarious gases and emanations disengaged from putrefying animal and vegetable substances, converting them into innocuous matter, and thus purifying and sustaining the entire salubrity of the atmosphere. In short, so hostile to organic

333. On some Secondary Physiological Effects produced by Atmospheric Electricity, by C. F. Schönbein, Med. Chir. Trans. vol. xxxiv. p. 205.

L'Ozone, ou Recherches Chimiques, Météorologiques, Physiologiques, et Médicales, sur l'Oxygène électrisé. Par H. Scoutellen, Paris, 1856.

miasmata, so incompatible with them, is ozone, that the presence of the latter enables us to affirm the absence of the former, and the healthiness of the locality in which it is found.

337. Ozone is produced in large quantities over lands covered with luxuriant vegetation, and over water.

338. Ozone is found in abundance on the sea-coast, and on mountains and elevated localities; yet, in reality, it does not progressively increase in quantity in the ratio of elevation, but its diminution or absence in the lower atmospheric strata depends on its destruction by miasmatic emanations with which it has come in contact, and which it has decomposed and rendered inert.

339. When the mean amount of ozone indicated by the ozonometer on the *sea-coast*, at an elevation of 85 feet, was 2·2, it amounted, *inland*, at the same elevation, to 0·6; at 170 feet to 1·3, and at 255 feet to 3·8.

340. Ozone, like the deutoxide of hydrogen, is remarkable for its bleaching properties. Its presence is more strongly marked during the night than in the day.

341. Pure ozone, perhaps on account of its exalted oxidising powers, is a most powerful poison, and when inhaled into the lungs, even in minute doses, produces deleterious effects, and in large doses quickly destroys the strongest animal life.

342. The inhalation of ozone produces great acceleration of the respiration, a painful constriction of the chest, not unlike asthma, spasm of the bronchial tubes, violent cough, irritation and inflammation of the mucous lining of the bronchiæ and air-passages, catarrhs, coryza, possibly "hay-fever," intense pneumonia, &c.

343. MM. Schifferdecker and Böckel, probably on insufficient data, believe there is no connection between ozone and bronchitis, pneumonia, &c.

344. Drs. Moffatt, Schönbein, and Scoutellen are of opinion

339. Glaisher, op. cit.

that a proper admixture of ozone and atmospheric air exercises an important influence on the animal economy, and is indispensably necessary to the due accomplishment of all the vital functions, and to the relief and modification of disorder and disease.

345. In confined places, where ozone cannot penetrate, plants and men become blanched; the skin grows pallid, the blood loses colour, lymph predominates, all the tissues soften, and serious diseases of the adynamic type break forth.

346. The presence of ozone in the atmosphere or water is readily detected by test paper prepared by saturating strips of white bibulous paper in a mixture made by boiling one drachm of *white* starch in an ounce of distilled water for three minutes, in which are to be dissolved, when cold, twelve grains of chemically pure iodide of potassium. The discoloration of paper, thus prepared, to *brown*, on exposure to the *atmosphere*, and to *purple*, when immersed in *water*, indicates the presence of ozone; the degree of discoloration, its intensity and amount. The change of colour is owing to the oxidation, by the ozone, of the potassium of the iodide, and by the combination of the iodine, thus set free, with the starch, to form an iodide of starch.

CHAPTER II.

THE SEASONS AND THE WEATHER.

THE SEASONS.

347. To the spherical figure of the earth, to its diurnal revolution on its own axis, and to the obliquity, with respect to the plane of the equator, of its motion in its elliptic orbit, by which every part of its surface between $23\frac{1}{2}$ north and south latitudes are in turn exposed to the perpendicular influence of the sun's rays, are to be ascribed the unequal distribution of heat and light, and the endless variations and vicissitudes of seasons in different latitudes.

348. The year is divided into four seasons of nearly equal duration—*Spring, Summer, Autumn, Winter.*

349. The *Spring* quarter commences *astronomically* in the northern hemisphere on the day on which the sun enters the first degree of Aries, about the 20th day of March, or, more strictly, on the day when the distance of the sun's meridian altitude from the zenith being on the increase is at a mean between the greatest and the least—the *vernal equinox.*

350. The duration of the spring quarter is 93 days.

351. *Summer* begins on the day on which the sun enters the first degree of Cancer, about the 21st of June, or, more strictly, on the day on which it has attained its greatest northern declination, or distance from the equator—the *summer solstice.*

352. The duration of the summer quarter is 93 days.

347. Prout, op. cit. p. 231.

353. *Autumn* commences on the day on which the sun enters Libra—about the 22nd of September, *i.e.* on the day on which the sun's meridian distance from the zenith, being on the decrease, is at a mean between the greatest and the least—the *autumnal equinox.*

354. The duration of the autumnal quarter is 90 days.

355. *Winter* begins on the day on which the sun enters Capricornus, about the 21st of December, when the sun's distance from the zenith is greatest—the *winter solstice.*

356. The duration of the winter quarter is 89 days, and in leap-year 90.

357. At the winter solstice the earth is about 3,000,000 of miles nearer to the sun than at the summer solstice. "As, however," says Sir J. Herschel, "the momentary supply of heat received by the earth from the sun varies in the exact proportion of the angular velocity, that is, of the momentary increase of longitude, so the greater proximity of the sun in winter is exactly compensated for by the earth's more rapid motion, and thus an equilibrium of heat is as it were maintained."

358. The intervals of time between the equinoxes are not equal, the sun's course in the ecliptic occupying seven more days on the northern than on the southern side of the equator. From the vernal to the autumnal equinox the course is completed in 186 days; from the autumnal to the vernal equinox in 179 days.

359. The division of the year adopted by the ancients, not only of Greece, but of other countries, differed very materially from that of the present day. The four seasons were of unequal duration, but were all astronomically distinguished.

360. With the Greeks, *Spring* began at the vernal equinox, and ended at the heliacal rising of the Vergiliæ or Pleiades, about the 7th of May.

361. *Summer* was calculated from the heliacal rising of the Vergiliæ, either to the heliacal rising of Arcturus, a star of the first magnitude in the constellation Arctophylax or Bootes,

which generally occurs about the middle of September, or to the heliacal rising of Sirius or Procyon—the former a star of the first magnitude in the constellation Canis Major, the latter in Canis Minor.

362. *Autumn* commenced at the heliacal rising of Arcturus, of Sirius, or of Procyon, about the 15th of September, and terminated at the heliacal setting of the Vergiliæ, which generally takes place about the beginning (5th) of November.

363. *Winter* was reckoned from the heliacal setting of the Vergiliæ to the vernal equinox.

364. The duration of the spring quarter was 48 days; of the summer quarter 131 days; of the autumn quarter 51 days; and of the winter quarter 135 days.

365. It is to be observed that this division of the year had especial reference to the climate of Greece.

366. "In Egypt, spring obtains during January and February; summer begins in March, and lasts to the end of August; autumn is distributed over September and October; and winter over November and December."

367. "Physicians," says Sennertus, "do not calculate the seasons by the sun's course, but by the temperature of the atmosphere. Spring is that season in which the constitution of the air is mild; summer, that in which it is hot and dry; autumn, that in which it is cold and dry; winter, that in which it is cold and humid." "Winter and summer are each distributed over four months and ten days; the spring over two months and some days; and the autumn over scarcely two months. In many septentrional and temperate regions, spring

361. All antiquity attributed an evil influence to the dog-star. Its heliacal rising was coincident with the overflow of the Nile, and with the oppressive and unhealthy forty days Etesian winds. The real classical dog-days are the twenty days preceding and following its heliacal rising.

366. Prosp. Alpinus, de Medic. Ægypt. lib. i. cap. vii.

367. Daniel Sennertus, M.D., tom. prim., Institutiones Medicæ, lib. quart., part. primæ, cap. ii. p. 578, Lvgdvni, 1650.

does not commence until after the vernal equinox; summer does not last four months; autumn commences before the heliacal rising of Arcturus; whilst the winter is scarcely able to accomplish five months."

368. The seasons, if the following lines from Lydiat may be received as evidence, were tolerably equally divided, and commenced a month earlier than the present corresponding astronomical quarters:—

Dat Clemens hyemem: dat Petrus ver Cathedratus:
Æstuat Urbanus: autumnat Bartholomeus.

Thus, winter began on the 23rd of November, spring on the 22nd February, summer on the 25th May, and autumn on the 24th August.

369. The seasons of the poet and of the agriculturalist have little in common with the arbitrary divisions of the zodiacal year, but everything in common with Nature. She herself mocks at these astronomical anachronisms. Spring is carolled in with the first burst of vegetation and the pairing of the feathered tribe. The snowdrop, crocus, modest primrose, rear their heads, and the raven and the blackbird hatch their young, during the astronomical "winter quarter." Hay harvest commences and early fruits are gathered in the astronomical "spring quarter." The luxuriant vine groans beneath the juicy grape, and wheat, barley, and hops are got in, during "summer;" whilst "autumn" is more especially remarkable for its snow and ice.

370. The astronomical division of the year would approach more nearly to nature were the spring quarter to commence at a point of the ecliptic equidistant from the winter solstice and the vernal equinox, viz. on the 3rd of February, and terminate at a corresponding point between the vernal equinox and summer solstice, on the 5th of May. The summer quarter would commence on this day, and end on the 6th August, on which day the autumnal quarter would commence: this would termi-

nate on the 5th November, on which day the winter quarter would begin.

The advantages of this division would be that the vernal equinox, equal day and night, would be placed in the *middle* of the spring quarter; the summer solstice, the longest day, *mid-summer*, in the *middle*, and *not at the commencement*, of the summer quarter; the autumnal equinox, equal day and night, would be found in the middle of the autumnal quarter; and the winter solstice, the shortest day, in the middle of the winter quarter, and not at the commencement as now. The spring quarter would consist of 91 days, instead of 93; summer of 93 days, as now; autumn of 91, instead of 90; and winter of 90, instead of 89.

371. Mr. Luke Howard suggests that the respective seasons should commence *fifteen* days *before* the equinoxes and solstices, in order that the yearly circle of the *varying temperature* may be divided into four symmetrical parts, more nearly corresponding with our *leafing* spring, *flowering* summer, *fruit-bearing* autumn, and *dormant naked* winter.

372. The great father of physic, in his treatise Περὶ Ἀὲρων, Ὑδάτων, καὶ Τόπων, sets out by stating that whoever would investigate medicine properly, and practise it successfully, should first consider the *seasons* of the year, and their different effects; the *winds* common to all countries, and those peculiar to each locality; the *aspect* of towns and cities in relation to the winds and rising of the sun; whether the *ground* be naked and deficient in water, or wooded and well-watered; and whether situate in a hollow confined locality, or on an elevated and cold site.

373. That the consideration of these subjects received at the hands of the ancient physicians the greatest possible attention, is evidenced in all their writings. Not only were they in the habit of studying the constitution of the season in which any epidemic or pestilential malady was prevailing, but they

371. Op. cit. vol. i. p. 35.

deemed it essential to take into calculation the peculiarity of the seasons of the previous year. This close and accurate observation of the meteorological conditions on which disease depends enabled them to predicate with almost unerring certainty, not only the advent but the very nature of an impending epidemy.

Thus, Hippocrates writes, "as the season and year advance he (the physician) can tell what epidemic diseases will attack the city, either in summer or winter," "and must (consequently) succeed in the preservation of health, and be by no means unsuccessful in the practice of his art." In *Aphorism* xi. sect. iii. we read, "If the *winter* be of a dry and *northerly* character, and the *spring rainy* and *southerly*, in *summer* there will necessarily be acute fevers, ophthalmies, and dysenteries." And in *Aph.* xiii. "If the *summer* be *dry* and *northerly*, and the *autumn rainy* and *southerly*, headaches occur in *winter*, with coughs, hoarsenesses, coryzæ, and in some cases consumption."

374. It may be observed, as a general rule, that all seasons are *unhealthy* which are *unseasonable*. Thus, cold and wet springs, cold and wet summers, warm and moist autumns, warm and wet winters, are, proverbially, fruitful sources of disease. The old saying, that "a green winter makes a fat churchyard," has long received the general assent of all classes. Moser, however, has laid it down that "elevation of temperature above the ordinary range diminishes the mortality of winter, and increases that of summer." The former is true only so far as it applies to the aged and the young, to both of whom severe winters are very fatal.

375. The ancient physicians were well aware of the unwholesome character of unseasonable weather; thus Hippocrates, *Aph.* viii. sect. iii. "In seasons which are regular, and

374. "The Influence of Temperature upon Mortality," by Dr. Buchner, Nederlandische Lancet, Feb. 1855.

furnish the productions of the season at the seasonable time, the diseases are regular, and come readily to a crisis; but, in inconstant seasons, the diseases are irregular, and come to a crisis with difficulty."

376. It has been laid down as an aphorism by Arbuthnot, that every season has its special diseases, not as a matter of accident, but as the result of fixed physical or chemical laws. In winter, those of the respiratory system prevail; in spring, inflammatory affections of the chest, and febrile disorders; in summer and autumn, that class of disorders predominates of which one of the essential symptoms is exudation from the intestinal surface, and from the liver; and in autumn fevers.

377. Of the seasons, the greatest mortality belongs to winter, the next to spring, then follows autumn, whilst summer affords the smallest number of deaths.

378. It has been observed that certain epidemic disorders, like seasons, recur about every fourteen or fifteen years. In other words, that a particular disease which occurred during a season marked by some peculiarity recurred during a subsequent season marked by similar peculiarities. If this be found to be universally the case, it will go far to establish the influence of weather in the production of disease.

379. Mr. Glaisher has shown that during a period of eighty-five years, in which the mean annual temperature at Greenwich has been recorded, "periods of cold years came together, and periods of warm years came together;" of the former, the maximum was gradually succeeded by that of the latter:—

Maxima of cold years, with the intervals of their returns—1771, (14) 1785, (14) 1799, (15) 1814, (15) 1829, (9) 1838, (17) 1855.

Maxima of warm years, with the intervals of their return—1778, (14) 1792, (14) 1806, (16) 1822, (10) 1832, (14) 1846.

379. Meteor, pp. 24, 22.

380. WINTER.—*January, February, March.*

381. The winters of our climate present every variety of weather. The days are short, cheerful, and sunny, or gloomy, overcast, or thickly clouded. The nights are calm and frosty, or darksome and disturbed by the howling of the south-west wind among the leafless trees; or a sharp north-east wind may blow throughout the day and night.

382. "Sometimes," says Washington Irving, "the tempest howls with redoubled fury; at others the cold and sleety rain falls thick and fast; the hoar frost spreads its snowy mantle o'er hedge and field; while the cloudless deep blue sky and the glowing east speak deceitfully of to-morrow's softness and beauty."

383. Our rivers, lakes, and ponds bound in icy chains, the frost, the snow, the leafless tree, the dreariness and desolation of the landscape, bespeak the wisdom and design of the beneficent interposition of the Almighty hand in assigning to the earth this season of the year as its sabbatical rest, its period of refreshing slumber and fertilising repose—the promise and the harbinger of a bounteous and plentiful harvest.

384. *Winds.*—The winds which regularly blow in

January are from	W. to N.
February ,, ...	S. to W.
March ,, ...	N. to E.

The annual average of seven years of the prevailing winds during this quarter is from

	Days.
N. to E. not including this last point. .	13·6
E. to S. ,, ,, . .	12·6
S. to W. ,, ,, . .	27·5
W. to N. ,, ,, . .	29·8
Variable	6·5
	90·0

381. Howard's London.

The W. and W.S.W. winds of this quarter are the chief cause of the mildness of the winters of this country.

The westerly winds of this season, attended with high reading of the barometer, are characterised by elevated temperature and absence of rain. Easterly winds are accompanied by a low temperature and sharp frosts.

385. *Rain.*—The annual average amount of rain during this quarter is 4·74 inches, and, according to Mr. Glaisher, 4·8 inches.

386. *Vapour,* mean elastic force of, 0·623 inch.

387. *Evaporation.*—Annual mean evaporation during this season is 4·709.

388. *Dew-Point.*—Mean annual temperature of, during the quarter, 35·433°.

The minimum temperature occurs some hours before sunrise; the maximum about the time of the maximum temperature of the air, from which time it gradually declines to the following morning.

389. The air of this quarter is nearly dry, and contains more oxygen than an equal volume in summer can contain.

390. *Electricity.*—The annual mean electrical tension of the air during this quarter is 46°.

The electricity of the atmosphere attains its *annual highest intensity* during the month of January.

391. *Barometer,* mean height of, 29·802 inches, being 0·124 inches above that of autumn. According to Mr. Glaisher, the mean height of this quarter, the result of fifteen years' observation, is 29·765 inches, corrected and reduced to 32° Fah. The mean winter range is 2·25 inches. The range of the mercurial column is greatest during this season. The *greatest daily mean pressure* for the year occurs about the 9th of January.

384. Howard's London.

A Manual of the Barometer, by John Henry Belville. London, 1849, p. 22.

388. Glaisher's Meteorology, p. 31.

392. *Temperature.*—The mean temperature of the season in this country is 37·76°. Mr. Glaisher makes it 39·333°.

393. The *second week* of this season, from 8th to 14th January, both inclusive, is the *coldest week of the year in "London,"* and also in "*London and its environs.*" On an average of *ten* years, from 1797 to 1806, the temperature of this week in "*London*" was 36·20° Fah.; and on an average of *twenty* years, from 1797 to 1816, the temperature of this week in "*London and its environs*" was 35·68° Fah. From 1841 to 1855 Mr. Glaisher's mean is 38·1°.

394. The *third* week of this season, from 15th to 21st January, both inclusive, is the *coldest week* of the *year* in the "*country.*" On an average of *ten* years, from 1807 to 1816, the temperature of this week in the "*country*" was 31·80 Fah.

395. January is the coldest month of the year in all latitudes.

396. *Diseases* of this quarter.—Inflammatory affections of the chest, bronchitis, pneumonia, cynanche trachealis, erysipelas, rheumatism, dysentery, and scarlet and typhus fevers.

397. Inflammatory affections of the chest are more likely to occur in a variable than in a steady low temperature.

398. Pneumonia and bronchitis most frequently arise in winter and spring, and whenever any sudden vicissitudes from heat to cold occur.

399. Rheumatism is most prevalent in January.

400. The termination of this and the commencement of the spring quarter are most favourable to the development of scarlet and typhus fevers. Damp warm and damp cold weather powerfully predispose to typhus fever.

401. This quarter is rather more fatal to dysentery than spring, less so than autumn.

402. The cold of winter, in checking the cutaneous excretion, frequently induces epistaxis and apoplexy.

403. The greatest mortality of the seasons belongs to this quarter.

393. Howard's London. Glaisher's Meteorology.

404. A severe winter cuts off a large number of old persons and young children.

405. SPRING.—*April, May, June.*

406. Spring is that season of the year in which the earth gradually exchanges its wintry robes for a mantle of the liveliest green; vegetation bursts forth in all the freshness and luxuriance of youth and boyhood; shrubs and trees put forth their buds and leaves, and flowerets of many a hue bedeck the landscape, and waft their fragrance on the balmy winds.

> And in yon mingled wilderness of flowers
> Fair-handed Spring unbosoms every grace;
> Throws out the snowdrop and the crocus first;
> The daisy, primrose, violet darkly blue,
> And polyanthus of unnumber'd dyes.

407. *Winds.*—The winds which regularly blow in

April are from	N. to E.
May	S. to W.
June	W. to N.

The annual average of seven years of the prevailing winds during this quarter is

From N. to E. not including this last point	24·0 days.
E. to S.	16·9
S. to W.	21·3
W. to N.	24·9
Variable	3·9
	91·0

408. *Rain.*—The annual average amount of rain during this quarter is 5·434 inches. According to Mr. Glaisher, 5·2 inches.

409. *Vapour.*—Mean elastic force of, 0·926 inch.

410. *Evaporation.*—Annual mean evaporation during this quarter, 10·129 inches.

411. *Dew-point.*—Mean annual temperature of, during this season, is 45·166°.

412. *Electricity.*—The annual mean electrical tension of the air during this quarter is 22°. The electricity of the atmosphere attains its *annual minimum intensity* in June.

413. *Barometer.*—Mean height of, 29·832 inches, being 0·030 inch above that of winter, and 0·045 inch below that of summer. The mean range of the barometer during this season is 1·81 inch. Mr. Glaisher makes the mean height 29·77 inches. The *greatest monthly mean pressure* occurs in June.

414. *Temperature.*—The mean temperature of this season is 48·94° Fahrenheit, or 11·18° above the mean temperature of winter, and 11·72° below that of summer. Mr. Glaisher's mean is 52·833°.

415. A snow-storm in the middle of this season is generally followed, within ten days, or at most within fourteen, by the first hot weather, during which swallows arrive.

416. A *wet* spring is not ungenial if succeeded by a warm and *dry* summer.

417. *Diseases* of this quarter.—Cynanche tonsillaris, cynanche trachealis, erysipelas, dysentery, typhus and intermittent fevers, catarrh, bronchitis, pneumonia, and pleuritis, in proportion to the prevalence of north-east winds, measles, and hooping-cough.

418. Typhus fever commences in May.

419. This season is less fatal to those labouring under dysentery than the winter quarter, but most inimical and fatal to phthisical patients.

420. Hippocrates, however, says, *Aph.* x., *sect.* iii. "*Autumn* is a bad season for persons in consumption." The learned translator, Dr. Adams, adds, "I am not aware that recent experience has furnished any grounds for questioning this opinion."

421. The statistical returns of the Registrar-general show that, in this country at least, *spring* is the quarter the most inimical to consumptive patients, and that *autumn* is the least

so. Dr. Richard Quain's experience and observation confirm this view. He says, "The cold easterly wind of spring completes the work which the winter had left undone."

422. It will be borne in mind that the autumn of Hippocrates commenced about the middle of September, and terminated about the beginning (5th) of November. (362.)

423. As the temperature of the year increases, phthisis, bronchitis, and pneumonia diminish.

424. SUMMER.—*July, August, September.*

425. This is the hottest season of the year, the atmosphere, under the more vertical rays of the sun in full north declination, having acquired the greatest quantity of heat and vapour.

Summer has been called the manhood of the year, the season of growth, and of development of power. The fields luxuriate in the abundance of their vegetable stores; the trees rejoice in their leafy pride; the varied flowers raise their heads; whilst beauteous nature revels in the soft voluptuousness of her own creation.

426. *Winds.*—The winds which regularly blow in

July are from	W. to N.
August	W. to N.
September	S. to W.

The annual average of seven years of the prevailing winds during this quarter is

From N. to E. not including this last point	18·8 days.
E. to S.	11·0
S. to W.	23·8
W. to N.	34·7
Variable	3·7
	92·0

The north-west wind is our fair-weather wind, and brings moderate weather and sunshine.

427. *Dry summers* are the consequence of *uniform* winds, from what quarter soever they may blow; as *wet summers* are of their *variation*, particularly if in opposite directions. These last are invariably *cold*.

428. *Rain.*—The annual average amount of rain which falls during this quarter is 6·683 inches. Mr. Glaisher's average is 7·5 inches.

429. *Vapour.*—Mean elastic force of, 1·231 inch.

430. *Evaporation.*—Annual mean evaporation during this season is 11·141 inches.

431. *Dew-point.*—An average of fifteen years shows the temperature of the dew-point during the quarter to be 52·90°.

The temperature of the dew-point during this season is lowest a little before sun-rise; as the sun ascends evaporation increases, the air receives a greater quantity of vapour, and as a consequence the dew-point increases until about noon, when it attains its maximum, and remains at this value until after the temperature of the air begins to decline, when it gradually decreases until the following morning.

432. The air in summer is warmer, moister, and less dense than in winter, and consequently contains less oxygen.

433. *Electricity.*—The annual mean electrical tension of the air during this quarter is 21·333°.

434. Thunder-storms occur more frequently in summer than in winter.

435. *Barometer.*—Mean height of, 29·877 inches, or 0·045 inches above the vernal mean, and 0·096 above the average of the autumnal quarter. The mean summer range is 1·08 inch. Mr. Glaisher's mean height, reduced to 32°, is 29·814 inches.

436. *Temperature.*—The mean temperature of this season is 60·66°, or 11·72° above that of the spring quarter. According to Mr. Glaisher, the mean is 59·933°.

437. The *twenty-eighth week* in the year, from 8th to 14th

431. Glaisher, Meteor. p. 31.

July, both inclusive, is the *hottest week in the year in the "country."* On an average of *ten* years, from 1807 to 1816, the temperature of this week *in the "country"* was 63·71° Fahrenheit.

438. The *thirty-first week* in the year, from 29th July to 4th August, both inclusive, is the *hottest week in the year in London,* and also *"in London and its environs."* On an average of *ten* years, from 1797 to 1806, the temperature of this week, in *London,* was 65·76° Fah. And, on an average of *twenty* years, from 1797 to 1816, the temperature of this week, in *"London and its environs,"* was 64·09° Fah.

439. July is the warmest month in the year in all latitudes north of the equator above 48°; and August in all lower latitudes.

440. Hot summers are not necessarily followed by cold winters.

441. *Diseases* of this quarter.—Diarrhœa, dysentery, cholera, typhus fever, and small-pox.

442. Typhus fever and diarrhœa prevail throughout the summer quarter.

443. This season is most fatal to dysentery, still more so to cholera.

During the years 1849 and 1854, cholera attained a fearful height during the last week of August, reached its maximum during the first and second weeks of September, and as rapidly declined during the third and fourth weeks of that month and the first and second weeks of October.

444. If cold and wet weather should take place in the middle of a hot summer, an augmentation of severity, or a state of disease before not in existence, will occur; and hence, also, severe epidemics arise, diarrhœa, dysentery, and cholera, particularly if to such a hot summer there should succeed a cold and rainy autumn.

445. AUTUMN.—*October, November, December.*

446. Autumn has from time immemorial been reputed to be the most unhealthy season of the year. Tertullian calls it "*Tentator valetudinum.*" "Autumnus Libitinæ questus acerbæ." Horace says,

> Frustra per autumnos nocentem
> Corporibus metuemus austrum.

447. This is the true rainy season of our climate.

448. The early part of this quarter is the most delightful portion of the year. A delicious calm often prevails for many days, or even weeks, in succession, amidst a brilliant sunshine. The latter part of the season and the beginning of winter are peculiarly subject to gales of wind from the S.W. A succession of south-west gales by night, and cloudy days with north-east winds, characterises the approach of the winter quarter, with all its gloom, its hoar-frosts, chilling breath, and howling storms.

449. *Winds.*—The winds which regularly blow in

October,	are from	S. to W.
November	,,	S. to W.
December	,,	S. to W.

The annual average of seven years of the prevailing winds during this quarter is from—

N. to E.	not including	this last point	17·2	days.
E. to S.	,,	,,	18·3	,,
S. to W.	,,	,,	30·0	,,
W. to N.	,,	,,	23·7	,,
Variable	,,	,,	2·8	,,
			92·0	

450. *Rain.*—The annual average amount of rain during this quarter is 7·947 inches. Mr. Glaisher makes it 6·9 inches.

451. The latter part of this season is marked by extensive and heavy rains from the south-west, the consequence in all probability of the Atlantic giving out more heat and vapour than the temperature of the air can sustain.

452. *Vapour.*—Mean elastic force of, 0·786 inch.

453. *Evaporation.*—Annual mean evaporation during this quarter, 4·488 inches.

454. *Dew-point.*—Temperature of, 40·933°.

455. *Barometer.*—Mean height of, 29·781 inches, being ·096 below the mean of summer. Mr. Glaisher's mean is 29·74 inches. The mean autumnal range is 1·49 inch. The *minimum daily mean depression* occurs towards the end of November. The *lowest mean monthly pressure* also occurs during this month.

456. *Temperature.*—The mean temperature of the season is 49·37°, or 11·29° below the mean of summer. Mr. Glaisher makes the mean temperature 44·6°. The temperature of this quarter declines daily.

457. *Dew.*—The *dews* of this season are very heavy and abundant.

458. *Asteroids* recur, with great regularity, between the 12th and 14th of November.

459. *Diseases* of this quarter.—Catarrhal ophthalmia, cynanche tonsillaris, bronchitis, pneumonia, congestion of the liver and mucous surfaces of the bowels, diarrhæa, dysentery, cholera, inflammation of the mucous surfaces generally, measles, scarlet and typhus fevers, apoplexy, phthisis, erysipelas, rheumatism.

460. The commencement of this quarter is most favourable to the developement of diarrhæa and scarlet and typhus fevers. The latter disease is most fatal during this quarter.

461. Bronchitis and pneumonia appear with the autumn quarter, attain the highest point at the commencement, and subside towards the end of the *winter* quarter.

462. This quarter is least inimical to phthisis. This disease

is most prevalent from the beginning of December to the commencement of the summer quarter.

463. Measles are most fatal during the middle and end of autumn.

464. Catarrhal ophthalmia prevails during November, and rheumatism during December.

465. This quarter is less fatal to dysentery than the summer season; and more so than winter.

466. Erysipelas is more prevalent during this season than in the summer.

467. Between the end of autumn and beginning of winter the greatest number of fatal cases of apoplexy and paralysis occur.

The Weather.

468. "To popular apprehension," says M. Arago, "the highest or ultimate object of meteorology is to enable us to foretel the weather. Looked upon in this point of view, science can as yet only offer abortive attempts, or such as hold out no promise for the future."

469. Under the term *weather* is to be comprehended the condition of the atmosphere with respect to temperature, humidity, winds, pressure, &c.

In this order we shall consider each of these subjects.

Temperature.

470. In Europe there are four different thermometrical scales in daily use.

471. *Fahrenheit's,* in which the freezing point is placed at 32°, the boiling point at 212°, the intervening number of degrees being 180.

472. The *Centigrade,* in which the freezing point is placed at zero, and the boiling point at 100°.

468. Op. cit. p. 389.

473. *Reaumur's*, of which the freezing point is zero, and the boiling point 80°.

474. *De Lisle's*, in which zero marks the boiling point, and 150° the freezing point.

475. Thus 180° of *Fahrenheit* are equal to 100° of *Centigrade*, to 80° of Reaumur, and to 150° of De Lisle. Or, 1 degree of the first is equal to $\frac{5}{9}$ of a degree of the second, to $\frac{4}{9}$ of a degree of the third, and to $\frac{5}{6}$ of a degree of the last.

476. If the *number of degrees between* any point of *Fahrenheit's* scale and 32° be multiplied by 5 and divided by 9, the quotient will give the corresponding point on the *Centigrade*. If multiplied by 4 and divided by 9, it will give the corresponding point on *Reaumur's* scale.

477. If any degree, either *above* or *below* zero, on the *Centigrade* scale be multiplied by 9 and divided by 5, or if any degree *above* or *below* zero of *Reaumur's* scale be multiplied by 9 and divided by 4, the quotient will in either case be the number of degrees *above* or *below* 32°, or the freezing point, of Fahrenheit.

478. Any degree of the *Centigrade* scale multiplied by 4 and divided by 5 will give the corresponding degree of *Reaumur's*; and conversely, any degree of *Reaumur's* multiplied by 5 and divided by 4 will give the corresponding degree of the *Centigrade* scale.

479. It were greatly to be desiderated, for uniformity's sake, that but one thermometrical scale be employed in all civilised countries. Were this to be settled and determined, there cannot be a doubt, even for an instant, that the Centigrade scale, upon every principle, ought to and would be that to which the preference should be universally accorded.

480. The diurnal temperature, irrespective of temporary causes of variation, is determined by the *sun's altitude at noon throughout the year*.

481. In England the annual mean temperature of the

country, deduced from observations made from 1817 to 1831, a period of 14 years, is 49·721°; that of the preceding 20 years is 49·649°.

482. The temperature of *London*, according to Mr. Luke Howard, is 1·579° higher; but, from the observations of Mr. Glaisher, it would appear to be only 0·6° above that of the country; whilst those parts of London which are situated at some distance from the Thames do not enjoy a higher temperature than is due to their latitudes.

483. The annual average temperature of the seasons is in

	Howard.	Glaisher.
Winter	37·76°	39·333°
Spring	48·94°	52·833°
Summer	60·66°	59·933°
Autumn	49·37°	44·600°

484. The mean temperature of the *summer half-year* is 56·524°; that of the *winter half-year* 41·718°; the difference between the two being 14·806°.

485. The mean of the *highest* temperature *by day*, on an average of 20 years, is 56·345°; that of the *lowest* temperature *by night*, 42·204°; the difference being 14·141°.

486. The difference between the mean temperature of day and night coincides, to a fraction of a degree, with the difference between those of summer and winter.

487. The *second week* in the year, from 8th to 14th January, is the *coldest* week of the year in *London* and its *environs* (393).

488. The *third week* in the year, from 15th to 21st January, is the *coldest* week of the year in the *country* (394).

489. The *twenty-eighth week* in the year, from 8th to 14th July, is the *hottest* week of the year in the *country* (437).

482. Howard, op. cit.
Glaisher, op. cit. p. 15.
Phil. Trans. Part XI. for 1850.
487. et seq. Howard's Climate of London.

490. The *thirty-first week* in the year, from 29th July to 4th August, is the *hottest* week of the year in *London* and its *environs* (438).

491. Extreme continued cold in this climate is always attended with deep snow in most parts of the country.

492. *January* is the *coldest month* in the year in *all latitudes; July* is the *warmest month* of the year in all latitudes north of the equator *above* 48°, and *August* in all lower latitudes.

493. All habitable latitudes enjoy a temperature of 60° for at least two months every year immediately preceding grain-harvest; below this temperature corn will not ripen. Wheat will not ripen if the *mean temperature* descend to 47·6°.

494. Vines require a mean annual temperature exceeding 49·50° Fah. The mean winter temperature must not fall below 33·4° Fah., and this must be followed by a mean summer heat of at least 64·4°. The vine cannot be successfully cultivated when the temperature is beyond 71°.

495. In order that the date-palm ripen its fruit, the mean annual temperature must exceed 70°.

496. M. Cotte has laid it down as an axiom that—

a. The extreme degrees of heat are almost everywhere the same; this, however, is not the case in regard to the extreme degrees of cold.

b. The thermometer rises to its extreme height oftener in the temperate zones than in the torrid zone.

c. It changes very little between the tropics: its variations, like those of the barometer, are greater the more one proceeds from the equator towards the poles.

d. It rises higher in the plains than on the mountains.

e. It does not fall so much in the neighbourhood of the sea as in inland parts.

f. The wind has no influence on its motions.

494. Kosmos, vol. i. p. 355.

g. Moisture has a peculiar influence on it, if followed by a wind which disperses it.

h. The greatest heat and the greatest cold take place about six weeks after the northern or southern solstice.

i. The thermometer changes more in summer than in winter.

k. The coldest period of the day is before sunrise.

l. The greatest heat in the sun and in the shade seldom takes place on the same day.

m. The heat decreases with far more rapidity from September to October than it increased from July to September.

n. It is not true that a very cold winter is the prognostic of a very hot summer.

497. *Effects of Temperature in inducing or averting Disease.*

Warmth.

498. Warmth lessens the tendency to, and diminishes the mortality from, *apoplexy.*

499. *Bronchitis* and *pneumonia* diminish as the temperature of the year advances.

500. *Diarrhœa* is materially aggravated by heat, and as sensibly mitigated by its decline.

501. In *hot* and *dry* weather *fevers* assume the *continued* form.

502. In *moist* and *suffocative* weather, with terrestrial emanations, the putrid remittent type prevails.

Cold.

503. Cold depresses the vital powers, and drives the blood to the internal cavities and mucous membranes, occasioning congestions, bronchitis, diarrhæa, and apoplexy.

504. *Apoplexy*, *epilepsy,* and *sudden deaths* frequently occur during a prevalence of hail and snow storms; *paralysis*, when snow-storms and high winds prevail.

504. Dr. Moffatt, Ass. Med. Journal, 1853, p. 747.

Rain.

505. The rains and drought of this climate are invariably dependent on the winds.

506. It has been shown that the winds which blow from W. to N. and from N. to E., indeed all those which blow from any point *north* of the equator, including the W. and E., are associated with our fair weather and our driest seasons; whilst those which blow from any point to the *south* of the equator, exclusive of the W. and E., but more especially from the S.E., are most intimately connected with our wet seasons, with floods and inundations.

507. Whilst the moon is far south of the equator there falls, in this climate, but a moderate quantity of rain; whilst she is crossing the equator towards these latitudes our rain increases, attains its maximum during the week in which she is in full north declination, or most nearly vertical to these latitudes, and during her return over the equator to the south the rain is reduced to its minimum quantity. This obtains in very nearly the same proportions both in an extremely dry and in an extremely wet season.

508. The annual average amount of rain which falls in this country is according to Mr. Howard 24·804 inches; to Mr. Belville 24·78; and to Mr. Glaisher 24·605 inches.

509. The monthly averages are—

507. Howard's London, vol. i. p. 181.
508. In London. Op. cit. vol. i. p. 106.
At Greenwich. Op. cit. p. 30.
Royal Observatory, Greenwich. Meteor. p. 67.

	From 1797 to 1816.	From 1815 to 1848.	From 1841 to 1855.
January	1·959 inch	1·68 inch	1·90 inch
February . . .	1·482 „	1·58 „	1·493 „
March	1·299 „	1·61 „	1·433 „
April	1·692 „	1·73 „	1·573 „
May	1·822 „	1·96 „	1·90 „
June	1·920 „	1·83 „	1·70 „
July	2·637 „	2·37 „	2·773 „
August	2·125 „	2·40 „	2·50 „
September . . .	1·921 „	2·40 „	2·34 „
October	2·522 „	2·67 „	3·06 „
November . . .	2·998 „	2·53 „	2·433 „
December . . .	2·427 „	2·02 „	1·50 „
	24·804 „	24·78 „	24·605 „

510. October appears to be the wettest month; next in order come November, July, and August.

511. The proportion of rain which falls in the four seasons of the year is in—

Winter	4·740 inches	4·87 inches	4·826 inches
Spring	5·434 „	5·52 „	5·173 „
Summer	6·683 „	7·17 „	7·613 „
Autumn	7·947 „	7·22 „	6·993 „
	24·804 „	24·78 „	24·605 „

512. On an average of years it rains in this country, more or less, nearly every other day, and on 23 or 24 days flood rains occur.

513. In some localities, however, rain falls almost daily; in other places the annual fall is below the average.

514. The number of days, of 24 hours, on which rain falls is fewer in the longest than in the shortest days, in the proportion of two to three.

515. One-fifth more rain would appear to fall during the night than in the hours when the sun is above the horizon.

516. More rain falls on mountains than on the plains, in the neighbourhood of the sea than at sea, and on the west coasts than on the east coasts.

517. About *one* year in *five* is subject to the *dry extreme*, and *one* in *ten* to the *wet extreme*. The wet years are uniformly *cold*, the dry invariably *warm*.

518. *Dry* years are most conducive to fevers and dysentery.

519. Many epidemics, plagues, and famines have occurred after parching droughts of the same or a previous year.

520. The summer of 1800 was unusually dry, no rain having fallen in London from 4th June to 19th August, except a very few partial showers. In this and the preceding year the crops failed greatly, and there was distressful scarcity. The mortality of the whole kingdom amounted to 185,970. The average number of deaths for 1776, and the three subsequent years, was 169,575.

521. During the three invasions of Asiatic Cholera the *deficiency of rain* was very remarkable. "The crisis of the disease," says Mr. Glaisher, "occurred at the droughtiest periods."

522. In 1832 "the rain-fall for the year was deficient by *one-fourth* of its average." In 1849, "no rain." In 1854, "total absence of rain."

The atmosphere, during the prevalence of the disease, "was deficient $\frac{1}{20}$th part of its usual average of aqueous vapour."

523. *Wet extremes* are also associated with disease.

524. Influenza, according to Hecker, has generally been preceded by *inundations* and *torrents of rain*.

525. The summer of 1799 was unusually wet and cold. Mean annual temperature 47·9° Fah. = 2·7° below the annual mean temperature of the five preceding and following years. The mortality of this year exceeded the mean annual mortality of the whole kingdom by 18,657.

520. Observations on the comparative Prevalence, Mortality, and Treatment of Different Diseases, by Sir Gilbert Blane, Bart. M.D. F.R.S. Med. Chir. Trans. vol. iv. pp. 108, 109.

521, 522, 523. Meteorology of London, p. 100.

525. Sir Gilbert Blane, Med. Chir. Trans. vol. iv. pp. 108, 109.

The Winds.

526. It has been already shown that winds are currents of air similar in kind to those of the ocean (117); that they tend to equalise the temperature of the surface of the globe (118); and to transport, by means of the clouds, the waters of seas and oceans into the interior of lands and continents, where water otherwise could never reach (189). Nor is the influence of the more violent movements of the atmosphere, storms and hurricanes, on the animal economy other than most salutary, by the free and perfect ventilation which they ensure, and by the dissipation and dilution of noxious gaseous emanations and exhalations, which they effect.

But, irrespective of this their general purpose, they possess peculiar, distinctive, and inherent characters and properties, depending on the quarter of the compass whence they blow.

527. The dryness, humidity, pressure, and temperature of the atmosphere, constituting "*the weather*," are intimately associated with and dependent upon the quarter whence the wind blows.

528. The chances are greatly in favour of rain following wind, from what quarter soever it may blow.

529. If the wind proceed from latitudes warmer than our own, it will, upon reaching our colder regions, and commixing with our atmosphere, deposit in the form of rain all that amount of moisture which the mean temperature of the two cannot suspend in the form of vapour.

530. The same result sometimes attends upon winds from higher and colder latitudes mixing with our warmer atmosphere.

531. The *strength* of the wind has a great and marked influence on health. In bronchial irritation wind is peculiarly prejudicial.

532. Captain Parry often supported a temperature of 0° Fah. without suffering any inconvenience when the atmosphere was

calm, whilst a cold of 20° Fah. was very annoying when accompanied by even a slight wind. In a *calm air,* the sensation produced by a temperature of — 55° Fah. might be compared to that experienced at 0° Fah. *with a breeze.*

"Not the slightest inconvenience was suffered from exposure to the open air, at a temperature of — 55° Fah. by a person well clothed, as long as the weather was perfectly calm; but in walking against a very light air of wind, a smarting sensation was experienced all over the face, accompanied by a pain in the middle of the forehead, which soon became rather severe."

533. It therefore follows that a certain agitation of the air will produce a sensation of cold equivalent to the effect of a fall of 55° Fah.

534. The wind blows least at sunrise and sunset; and most violently an hour or two after noon.

535. The *north wind* (Septentrio, 'Απαρκτίας,) is dry, cold, and heavy, and is generally accompanied with clear, dry, and serene weather.

536. North winds prevail in the middle of winter, and are connected with our *driest* season about the vernal equinox. North to north-east winds predominate during March and April.

If the barometer fall with this wind, the worst possible weather sets in; in winter, deep snows and severe frosts; and in summer, cold rains and violent storms.

537. The northerly winds are deficient in *electric force.* Those which blow from N.N.W. to N. possess but 102 degrees of *electric force;* those from N.N.E. to N.E. 139 degrees.

538. M. Quételet, the learned astronomer royal of Belgium, to whom we are indebted for these statements, and who has occupied himself for the last five years in ascertaining the average annual amount of electricity in the different winds, has

532. Journal of a Voyage for the Discovery of a North-West Passage, 1821, p. 145.

found that the above are the two "*minima*" of the whole; and that those which blow from W.N.W. to N.W., and from E.S.E. to S.E. are the two "*maxima*," the former evidencing 272 degrees, and the latter 312 degrees.

539. The annual average *number of days* during ten years, in which the prevailing wind in this country blew from west to north, not including the latter point, was ascertained by Mr. Luke Howard to be 100·4, the greatest number being 124, and the least 83.

540. North winds, with a tendency to north-east, give rise, according to Mr. Hingeston, to cholera.

541. Wet northerly winds disturb the digestive organs.

542. The *North-east* wind (Aquilo, *βορέας*, Etesias), in the north-western parts of Europe, is cold, sharp, dry, and heavy.

543. M. Monge, in explaining the cause of the peculiar characters of this wind, observes, that currents of air from this quarter, in their passage over mountain districts, lose, from elevation and diminished atmospheric pressure, a portion of their aqueous vapour, acquire a consequent increased density, and sustain a loss of temperature; that, in their onward progress they rush down on the lower lands of Poland and of the north of Germany, where, from their being far below the point of saturation, they occasion an abundant evaporation of the water of the lower strata of the atmosphere, and that this, by carrying off caloric, contributes further to the production of the cold peculiar to this wind. The specific gravity of the atmosphere is hereby increased, and the mercurial column rises in the barometer.

544. This wind is our dry-weather wind, and has been shown by Mr. Howard to bear as close a relation to dry weather as does the south-east wind to rain.

545. North-east winds prevail during the months of March

539. Op. cit. 2nd edit. vol. i. p. 75.

543. Annales de Chimie.

544. Howard's Climate of London.

and April, and are the great evil of the end of our winter and the commencement of our spring quarters.

546. Winds which blow from the N.E. to E.N.E. possess 174 degrees of *electric force.*

547. "The 'elasticity of vapour' is," according to Dove, "least with this wind."

548. North-east winds are fatal, in an extreme degree, to phthisical patients, and hurry hundreds to the grave (421).

549. The *east wind* (Solanus, Ἀπηλιώτης) is dry and cold. It partakes of all the properties of the north-east wind, and is intimately associated with our *driest* season about the vernal equinox.

550. Easterly winds, having traversed the continents of Asia and Russia, contain but little aqueous vapour, and no ozone.

551. If the barometer fall with an east direction, the wind will go round to the south, unless heavy snow or rain follow immediately.

552. The *electric force* of winds which blow from E.N.E. to E. is 184.

553. The annual average *number of days* during ten years, in which the prevailing wind in this country was from north to east, not including the latter point, was, according to Mr. Luke Howard, 74·4.

554. East winds blow chiefly during the day.

555. Cynanche trachealis, laryngitis, bronchitis, and pneumonia, are some of the diseases induced by this wind.

556. East winds are most fatal to those labouring under phthisis, and are said to re-excite ague.

557. The *south-east wind* (Euro, Auster, Εὐρονοτος) is moist, and, when rain is not falling, is cold and chilly.

558. This wind is peculiarly associated with the rain of our climate, and has been shown by Mr. Howard, on an average of ten years, to bear an undeviating relation to the quantity of

549. Howard.

551. Belville, op. cit. p. 20.

rain which falls. Indeed, so marked is this correspondence, that this wind may be considered our *rainy* wind.

559. The south-east wind is intimately connected with electrical indications, with hail and with thunder.

560. The *quantity of electricity* contained in winds which blow from E.S.E. to S.E. is 312°, one of the two "*maxima*" of *electric force.*

561. Cholera and influenza are especially associated with the prevalence of this wind.

562. Bronchitis, cynanche parotidea, diarrhœa, and dysentery are among the diseases induced by this wind.

563. This is one of the equatorial or ozoniferous winds which extend from S.E. to N.W. by way of the S. and W.

564. The polar or non-ozoniferous winds are those which blow from any other point on the north side of the equator.

565. Dr. Moffatt is of opinion that more *diseases* occur during a prevalence of ozone or equatorial winds, and more *deaths* during polar or non-ozoniferous winds. The latter circumstance he attributes to the reduction of temperature; the former to the excess of ozone.

566. The *south wind* (Notus, the Ἀργέστης Νότος of Homer,) is always associated with humidity and an elevated temperature, though few winds are more cold and "searching" than is the wind from this quarter *before* the rain falls.

567. Southerly winds are invariably accompanied with rain, in most parts of Europe at least, and probably in the greater portions of our hemisphere. Their rainy character is proverbial. They are intimately connected with the *wet* season following the autumnal equinox.

568. South to west winds are the prevailing winds of autumn, and of the middle of winter.

569. Winds which blow from S.S.E. to S. contain 261° of *electric force.*

565. Ass. Med. Journal, 1853, p. 747.

567. Howard.

570. Annual *average of days*, according to Mr. Luke Howard, on which the prevailing wind is from east to south, not including the latter point, is 53·9.

571. Ancient writers attached a vast amount of odium to this wind, which Mr. Haviland thinks it justly merits. Galen says moist weather produces fluxes of the belly; Aristotle, that the south wind is moist and heavy.

572. The pressure of the atmosphere during a southerly direction undergoes great changes, as evidenced by the oscillations of the barometer, of which the lowest depressions occur with this and the south-west wind. A fall of the mercurial column, with a south wind, is invariably followed by rain, and in winter is attended with thunder. If the fall be considerable, severe but short gales arise; if sudden, violent storms succeed.

573. South winds are highly ozoniferous, and probably, on this account, produce catarrhs and bronchitis. They soothe and allay a dry and irritable condition of the mucous surfaces of the air tubes and cells, and greatly alleviate the sufferings, and indefinitely prolong the existence, of the phthisical patient.

574. The *south-west wind* (Austro Africus, Λιβάνοτος, stormy zephyr,) is warm and moist, and generally brings gales, and rain in abundance, especially towards the latter part of autumn and beginning of winter.

575. This wind, like the south and west wind, is associated with the wet season following the autumnal equinox, and is almost invariably accompanied, if not preceded, by a falling barometer.

576. The Atlantic, in the interval between the autumnal equinox and the winter solstice, is probably the source of our rains from this quarter. The west and south-west winds, in

571. Climate, Weather, and Disease, by Alfred Haviland, London, 1855, p. 126.

Aristotle, Lib. viii. Hist. cap. xv.

572. Belville.

passing over this ocean, become saturated with moisture, and charged with ozone.

577. The winds between south and west have no marked connexion with either a wet or dry *year.*

578. The annual average number of degrees of *electric force* of winds which blow from S.S.W. to S.W. is 243.

579. From the deduction of the gyratory law of winds by Dove, it appears that in our northern zone "the elasticity of vapour is greatest with this wind."

580. The south-west wind, charged with all the purity and freshness of the Atlantic breezes, and a large amount of ozone, is eminently conducive to health. From its increased moisture and elevated temperature it is exceedingly prone to aggravate chronic bronchitis, and is as singularly calculated to alleviate the sufferings and prolong the existence of the phthisical patient.

581. The stormy character of this wind did not escape our immortal bard in the malediction which he makes Caliban heap upon Prospero and Miranda:—

> "a south-west blow on ye,
> And *blister* ye all o'er."

582. During the prevalence of south and south-west winds there is little variation of temperature between the day and night, in consequence of the sun's rays being prevented reaching the earth by the dense vapour with which the air is loaded.

583. Southerly winds, from their elevated temperature, have a tendency to ascend acclivities, whilst north or mountain winds have an opposite inclination.

584. The *west wind* (Favonius, *Ζέφυρος*, clear blowing zephyr of Homer), like the north-east wind, is associated with our fair weather.

585. The west wind, and those which range from this point to N.N.W. are the predominating winds of summer.

581. Tempest, act i. scene ii.

586. On the contrary, the west wind, and those which range from this point to south, are the prevailing winds of winter.

587. The west wind is associated with the *wet* season following the *autumnal* equinox.

588. Westerly, or W.S.W. winds, in both temperate zones, are the prevailing counter-currents to the trades or east winds of the tropics. In this country the winds from these points blow for a greater number of days, without intermission, than from any other quarter, and are the principal cause of our mild winters.

589. If a sudden and considerable fall of the barometric column take place with a west wind, a violent storm from the north-west or north will follow.

590. In the United States storms *invariably* come from the west, and sometimes last two or three days.

591. The *amount of electricity* contained in winds which blow from S.W. to W. is 220°. In those which blow from W. to W.N.W. 261°; from W.N.W. to N.W. 272°, the second of the two "*maxima*"; and, in those from N.W. to N.N.W. the degrees of *electric force* are but 160.

592. The annual average *number of days* on which the prevailing wind is from south to west, not including the latter point, is 104·4.

593. The healthfulness of the west wind has become proverbial.

594. The west wind blows, for the most part, at night.

594. The *north-west* wind (Chorus, Ἰάπυξ) is our fair-weather wind, and brings moderate weather and sunshine, so long as it is not interfered with by southerly currents.

595. It is one of the prevailing winds of the summer quarter.

596. A fall of the barometric column with this wind is followed, in summer, by cold rains; in winter by severe frosts.

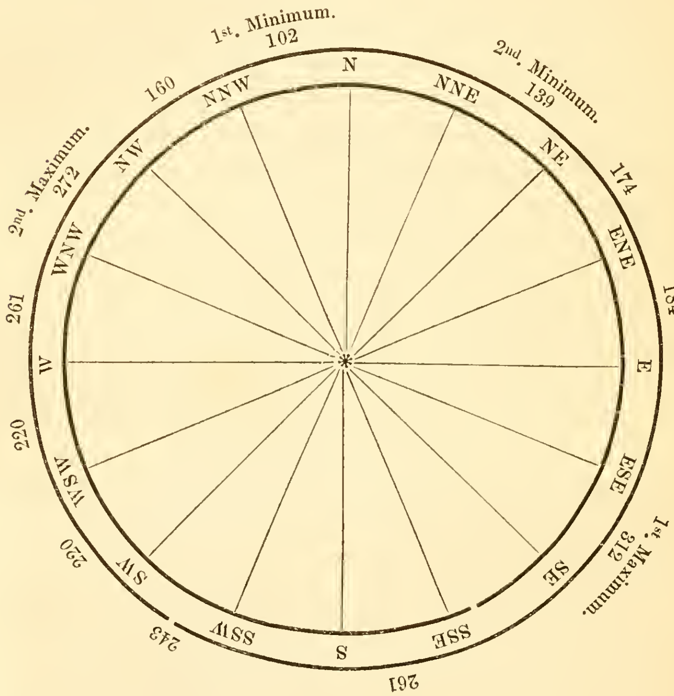
597. During the prevalence of the epidemic cholera in 1854

588. Kosmos, vol. i. p. 350.

589. Belville, op. cit. p. 20.

Mr. Glaisher found the wind blew nearly three times more frequently from between south-west and north-west than from any other point of the compass.

598. The following diagram, for which we are indebted to Professor Faraday, exhibits the average annual amount of *electric force* possessed by the various winds, as determined by M. Quételet:—



599. The *harmattan, simoom,* and *sirocco,* are met with in warmer latitudes.

600. The harmattan is a singularly dry, hot, parching easterly wind, which blows, occasionally, for several days in succession, from the interior of Africa towards the Atlantic.

598. Sur le Climat de la Belgique, vol. i. p. 20.
600. Mr. Norris, Phil. Trans. vol. lxxi.

This wind is always accompanied by a thick haze or fog. It destroys all vegetable production, burns up the leaves of evergreen shrubs and trees, and blisters the hands and face of the human subject. Singularly enough it restores to health and life those labouring under fevers, arrests the spread of epidemics, the contagion of small-pox, and renders inoculation inert, and of none effect.

601. Dr. Lind differs materially on this point. He considers the harmattan a "malignant and fatal wind."

602. The *simoom* blows during April and May over the deserts from all points of the compass. It is an excessively hot wind, "similar to a blast from a furnace," or "burning oven," surcharged with fine sand, rapidly alternating with cold pestilential puffs of a putrid and sulphureous smell.

603. This wind, like the harmattan, withers the vegetation over which it blows, and in man produces instant suffocation, or at the least asthma, and leaves the sufferer for years in a state of extreme prostration and depression.

604. The simoom, the approach of which is very rapid, is recognized by a red or purple haze in the horizon, the consequence of its extreme dryness (186), but which is supposed by the Egyptians to represent the red colour of the body of Typho, the spirit of drought and death.

605. The simoom is the qādīm, or *east wind* of the Old Testament. Its effects on animal and vegetable life are alluded to by Job xv. 2, "Shall a wise man fill his belly with the east wind?" and it is more particularly referred to in Hosea xiii. 15, "though he be fruitful among his brethren, an east wind shall come, &c." and in Ezek. xvii. 10, xix. 12, "shall it not utterly wither when the east wind toucheth it?" "the east wind dried up her fruit."

601. Diseases of Hot Climates.

602. A Vindication of the Authorised Version of the English Bible, by the Rev. S. C. Malan, M.A. London, 1856, p. 83, *et seq.*

Journal of Sacred Literature, by E. Robinson, LL.D. vol. i. p. 305.

606. In Hebrew, as in Arabic, qādîm, and shŭrqiyeh, the name by which the easterly winds of Palestine are called at the present day, are applied to the winds which have great affinity with each other, and blow from E.N.E., E., E.S.E. or S.E.

607. The *sirocco* is a hot stifling wind peculiar to Italy and Dalmatia. It blows during the day about Easter from the S.S.E., and usually lasts twenty days.

Its effects are exceedingly enervating, and productive of great languor and lassitude.

608. *Calms.*—In contradistinction to winds are calms. These are the effects merely of the absence of the aerial currents, and consist in a stagnant, gloomy, overcast, misty or hazy condition of the atmosphere.

609. Calms are unquestionably productive of the most baneful and pernicious consequences, by favouring the concentration of miasmata, and of animal and vegetable effluvia, particularly among a crowded and uncleanly population; and by delaying those changes in the atmosphere which are necessary to the renewal of its purity.

610. Calms contribute in the highest possible degree to the production, aggravation, and propagation of epidemic disease, and are associated with plagues and pestilence.

611. We read in Maitland's "History of London," that for several weeks before the plague made its appearance in London, in 1665, there had been an uninterrupted calm. Dr. Baynard, a cotemporary writer, confirms this fact. Diemerbroeck, in giving an account of the plague at Nimeguen, mentions a similar condition of the atmosphere.

612. During the most fatal periods of the three visitations of the pestilential cholera, this still and oppressive condition of the air was observed to prevail, not only in this country, but in every city, town, or locality throughout Europe where the disease appeared. From the 1st July to 31st October, a period

611. De Peste, lib. i. cap. vi.

612. Glaisher, op. cit. p. 66.

of 123 days, a calm was noted on 65 days, more than one-half of the whole number. In July the greatest pressure of the wind on the surface of a square foot was 2 lbs. in one instance.

613. The disease proved most fatal in those localities where the atmosphere was the calmest.

614. The Barometer.—We have already stated, when speaking of the *barometer,* that a column of mercury 30 inches high, exactly counterpoises a column of air, of an equal base, extending from the sea-level to the top of the atmosphere (35). We have also stated that should the atmospheric pressure be diminished or increased by any disturbing causes, by rarefied or by denser atmosphere, the mercury in the tube will either fall or rise in a corresponding degree (36).

615. The application of the barometer in measuring heights of mountains and other elevated localities, has been already exemplified (37 to 48). We have now to treat of the barometer in connection with the *weather.*

616. The fall and rise of the barometer depend on, and bear a due relation to the variations in the density of the atmosphere.

617. These variations are caused by unequal distribution of heat, and consequent production of winds (117), both of which are intimately concerned in the precipitation of rain.

618. The *mean annual height* of the barometer in this country, according to Mr. Howard, is 29·823 inches; to Mr. Belville, 29·872 inches; and to Mr. Glaisher, 29·772 inches.

619. Its *average annual range,* the result of 17 years' obser-

619. On the 5th Feb. 1821, wind N.W., mean temp. 31°·50, new moon on 2nd, the barometer rose to 30·80 inches; and on the 24th December of the same year, wind S., mean temp. 43°, new moon, it fell to 27·80, a depression and range in London nearly without a precedent on record. On the following day, at the Royal Observatory, Greenwich, the reading of the barometer was 27·89 inches only. In 1778, Sir George Shuckburgh observed the barometer in London at 30·935 inches, the highest reading ever seen.

vations, is 2·07 inches. It very rarely rises as high as 31 inches, or falls below 28·50 inches.

620. The *maximum* height of the barometer takes place during the first three months, and the *minimum* height during the last three months of the year. The former is connected with northerly and the latter with southerly winds.

621. The mean height of the barometer in this country during the four seasons is in—

	Howard.	Glaisher.
Winter	29·802	29·765
Spring	29·832	29·770
Summer	29·877	29·814
Autumn	29·781	29·740

622. The barometer falls before rain or wind, and rises during or subsequently to it.

623. The fall which precedes wind, and the oscillations of the mercurial column which accompany violent storms and hurricanes, depend on very great rarefaction of the atmosphere.

624. Warm dry air weighs heavier than cold and damp air. The former elevates, the latter depresses, the barometric column. The denser the atmosphere, the higher is the mercury; the more rarefied the air, the lower the barometer.

625. The *range* of the barometer, which within the tropics is comparatively small, *increases with the latitude,* on account of the diminution of temperature, and consequent increase of density of the atmosphere.

626. The *greatest daily mean pressure* for the year occurs about the 9th of January, and the *minimum daily mean depression* towards the end of November.

627. The *greatest monthly mean pressure* occurs in June, and the *lowest* in November. A *second maximum* occurs in January, and a *second minimum* in March.

628. Mr. Howard has ascertained that the barometer in London, on a mean of ten years, suffers in moderate and

settled weather a *depression* of about one-tenth of an inch at new and full moon, the consequence of the greater influence of these phases, in comparison with the first and third quarters, in the production of regular lunar atmospheric tides, on which the fall depends.

629. The influence of the moon on the temperature and density of our atmosphere appears to be exercised chiefly through the medium of the winds.

630. A tolerably constant relation obtains *between* the *movements* of the *barometer* and the *variations* of the *temperature* of the atmosphere.

631. In the early cold periods of the year, and in the fine weather of summer, *opposition* in movements predominates; but in the decline of the year, when the atmosphere is losing both heat and water, and when the season is tending to rain, the movements are in the *same direction.*

632. Two degrees of Fahrenheit are equivalent in these variations to a tenth of an inch of the barometric column.

633. *Every inch* which the barometer rises or falls either elevates or depresses the *boiling-point* of water by about 1·76°. M. de Saussure found water boil at the top of Mont Blanc at 187·099° Fah.

634. Periods of epidemic and pestilential diseases are associated with an unusually high state of the barometric column.

635. During the height of the three epidemic visitations of cholera, in 1832, 1849, and 1854, the pressure of the atmosphere was remarkably and continuously high.

On the 18th February, 1832, the reading of the barometer was 30·60 inches. On the 11th February, 1849, it reached to 30·91 inches: "A reading not likely," says Mr. Glaisher, "to occur but once in 30 years." During the third outbreak of the disease, in 1854, the reading was as high as 30·50 inches.

636. The exceeding density of the atmosphere indicated by this extreme height of the barometer would retard, if not prevent, vaporous diffusion; and, as a consequence, would materially aggravate the stagnation of miasmatic exhalation.

637. The mean weight of a cubic foot of air for the year was found to be two grains above the average.

638. The decline of the disease appeared in some measure to be connected with decreased reading of the barometer; as this occurred, the number, virulence, and mortality of the attacks lessened.

639. The minimum reading of the barometer was 29·25 inches. This was accompanied by a violent storm of wind, of which the horizontal pressure amounted to 20 lbs. on the square inch.

640. If the atmospheric pressure from any disturbing cause be suddenly diminished, the cutaneous vessels become distended, and pour out on the slightest exertion an abundant perspiration. If the fall of the mercurial column be large and rapid, numerous sudden deaths will occur.

Of the Barometer, as affording indications of the Weather, of Rain, Snow, Winds, Storms, &c.

641. Dr. Halley, John Patrick, M. Cotte, and others, have laid down certain rules for our guidance in the use of the barometer as a *weather-glass.* The following embrace all that is worthy of notice in these different axioms, together with much that is interesting on "*the indications of the winds by means of the barometer and thermometer.*"

642. In applying these rules, it should be borne in mind that the changes in the atmosphere indicated by the barometer may occur in the upper part only, and may not extend to and be observable at the surface of the earth; and that variations in the weight of the atmosphere over any given district may arise, not from changes of wind or weather in that district, but from changes in the atmosphere of an adjoining district.

636, 637, 638. Glaisher.
642. Phil. Trans. No. 187.
Dr. Harris's Lexicon Technicum, 1716.

(1.) Indications of approaching changes of weather, and especially of the direction and force of winds, depend less on the absolute height of the mercury in the tube, than on its falling and rising.

(2.) A height of 30 inches at the level of the sea is more indicative of settled weather and steady winds than any other height.

(3.) The barometer is said to be *falling* when the mercury in the tube is sinking, at which time its upper surface is almost always concave or hollow; the barometer is said to be *rising*, when the mercurial column is lengthening, and its upper surface is convex or rounded.

(4.) The *rising* of the mercury presages in general fair, and its falling foul, weather, as rain, snow, high winds, and storms.

(5.) Below 30 inches the probability of rain is in an increased proportion with equal decrements of the mercurial column; above 30 inches the probabilities of fine weather are in a diminishing proportion with equal increments.

(6.) In calm weather, when the air is inclined to rain, the mercury is commonly low.

(7.) It sinks *lowest* in very great winds, though these be unattended with rain.

(8.) In very hot weather the falling of the mercury forbodes thunder.

(9.) In winter the rising presages frost; and in frosty weather, if the mercury, which is generally high, fall three or four tenths of an inch, a *thaw* will *certainly* follow; but in a *continued frost*, if the mercury rise, it will *certainly snow*.

(10.) A rapid rise of the barometer indicates the approach of unsettled weather; a slow rise, the reverse.

(11.) A considerable and rapid fall is a sign of stormy weather, though of short duration, and is usually accompanied with rain.

(12.) A sudden rise in the barometer during a storm indicates that the worst is over.

(13.) The greatest depressions of the barometer are accompanied by rain and gales from the south and south-west; the greatest elevations by north-west, north, and north-east winds.

(14.) Although the barometer almost always falls with a southerly and rises with a northerly wind, the reverse sometimes occurs, in which case the southerly wind will be dry, and the weather fine, whilst the northerly wind will be wet and violent.

(15.) When the barometer sinks considerably, high winds, rain, or snow will follow: the wind will be from the northward, if the thermometer is low for the season; from the southward, if the thermometer is high.

(16.) If, when the wind is from any point between north-west and north-east, the barometer fall and the thermometer rise, the wind will shift to the south.

(17.) If, when the wind is from any point between east and south-west, the barometer fall, an increasing gale from that quarter will ensue, which will be of shorter or longer duration according as the fall is rapid or slow.

(18). Sudden falls of the barometer, with the wind from west, are frequently followed by violent storms from north-west or north, during which the mercury will rise to its former height.

(19.) If a gale set in from the east or south-east, and the wind veer by the south, the barometer will continue falling until the wind becomes south-west, when a comparative lull may occur; after which the gale will be renewed, and the veering of the wind towards the north-west will be indicated by a rise of the barometer and a fall of the thermometer. These gales, which are accompanied by unusually high tides and the heaviest seas, are supposed to have a rotatory movement (101, 102, 103, 104). When a lull in the course of the storm occurs, it is a sign that the centre of the revolving gale is passing over or near the place of observation.

(20.) If, after a storm of wind, the mercury remain stationary,

fine weather, with the wind from the same quarter, will continue until the barometer begins to rise or fall, when a change may be looked for.

643. Dr. Kirwan has endeavoured to deduce, from observations of the weather extending over a period of forty-one years, the probable chance of particular seasons being followed by certain other seasons; thus,

The probability is—

1 to 2	that a *dry spring*	will be followed by	a *dry summer*.
4 to 11	,, ,, ,, ,,		*wet* ,,
3 to 22	,, ,, ,, ,,		*variable* ,,
0	,, *wet spring* ,, ,,		*dry* ,,
5 to 6	,, ,, ,, ,,		*wet* ,,
1 to 6	,, ,, ,, ,,		*variable* ,,
5 to 11	,, *variable spring* ,, ,,		*dry* ,,
7 to 11	,, ,, ,, ,,		*wet* ,,
1 to 11	,, ,, ,, ,,		*variable* ,,
5 to 16	,, *dry summer* ,, ,,		*dry autumn*.
5 to 16	,, ,, ,, ,,		*wet* ,,
3 to 8	,, ,, ,, ,,		*variable* ,,
1 to 4	,, *wet summer* ,, ,,		*dry* ,,
3 to 20	,, ,, ,, ,,		*wet* ,,
3 to 5	,, ,, ,, ,,		*variable* ,,
1 to 5	,, *variable summer* ,,		*dry* ,,
3 to 5	,, ,, ,, ,,		*wet* ,,
1 to 5	,, ,, ,, ,,		*variable* ,,
3 to 11	,, *dry spring* and *dry summer*		*dry* ,,
4 to 11	,, ,, ,, ,,		*wet* ,,
4 to 11	,, ,, ,, ,,		*variable* ,,
1 to 4	,, *dry spring* and *wet summer* ,,		*dry* ,,
0	,, ,, ,, ,,		*wet* ,,
3 to 4	,, ,, ,, ,,		*variable* ,,
0	,, *wet spring* and *dry summer*		*dry* ,,
0	,, ,, ,, ,,		*wet* ,,
0	,, ,, ,, ,,		*variable* ,,
2 to 5	,, *wet spring* and *wet summer*		*dry* ,,
1 to 5	,, ,, ,, ,,		*wet* ,,
2 to 5	,, ,, ,, ,,		*variable* ,,
1 to 41	,, *wet spring* and *variable summer*		*dry* ,,
0	,, ,, ,, ,,		*wet* ,,
0	,, ,, ,, ,,		*variable* ,,

The probability is—

0	that a *dry spring* and *variable summer*	will be followed by	a *dry autumn*.
2 to 3	,, ,, ,, ,,		*wet* ,,
1 to 3	,, ,, ,, ,,		*variable* ,,
1 to 2	,, *variable spring* and *dry summer*		*dry* ,,
0	,, ,, ,, ,,		*wet* ,,
1 to 2	,, ,, ,, ,,		*variable* ,,
1 to 7	,, *variable spring* and *wet summer*		*dry* ,,
1 to 7	,, ,, ,, ,,		*wet* ,,
5 to 7	,, ,, ,, ,,		*variable* ,,
0	,, *variable spring* and *variable summer*		*dry* ,,
1 to 41	,, ,, ,, ,,		*wet* ,,
0	,, ,, ,, ,,		*variable* ,,

A season is termed *wet* when it contains *two* wet months, or when the quantity of rain which falls exceeds five inches. A *dry* season is one in which the quantity of rain which falls is less than five inches. *Variable* seasons are those in which there fall between 30 and 36 pounds of rain. A pound of rain is equal to ·157637 of an inch.

A *dry spring* is *always* followed by a *rainy winter*.

Wet summers are generally followed by *severe winters*.

A *moist* and *cold summer*, and *mild autumn*, are sure signs of a *hard* and *severe winter*.

A *moist autumn*, with a *mild winter*, is generally followed by a *cold and dry spring*.

A *severe autumn* forebodes a *windy winter*.

A *rainy winter* predicts a *sterile year*.

A *frosty winter* is followed by a *dry summer*.

A *mild winter* is succeeded by a *wet summer*.

Springs and *winters*, if *dry*, are *cold;* but *warm*, if *moist*. On the contrary, *summers* and *autumns*, if *dry*, are *hot;* and the *former*, if *moist*, are *cold*.

Dr. Kirwan states, as the result of numerous observations, that,

If the last week in February, and the first fortnight of March, be rainy, and attended with frequent appearances of the rain-bow, a *wet spring* and *summer* may be expected.

When there has not been any storm before or after the vernal equinox, the ensuing *summer*, five times out of six, is *dry*.

If there be a storm on the 19th, 20th, 21st, or 22nd of March, from the S.W. or W.S.W. the succeeding *summer*, five times in six, is *wet*.

When a storm arises from an *easterly* point, on the 19th, 20th, or 21st of March, the succeeding *summer*, four times in five, is *dry*.

When a storm arises in any point, on the 25th, 26th, or 27th of March, and not before, the succeeding summer, four times out of five, is *dry*.

When it rains plentifully in March, it will rain but little in September, and *vice versâ*.

About one year in five is characterised by extreme drought, and one in ten by extreme wet. The latter is uniformly cold, the former uniformly warm.

A hot summer, says Humboldt, is not necessarily followed by a cold winter.

A windy season can scarcely fail, in some part, to be wet.

CHAPTER III.

RESPIRATION AND CIRCULATION.

Before entering upon the further consideration of our subject, it is desirable we should take a brief survey of *respiration* and its phenomena, both in the vegetable and animal kingdom.

644. Respiration is common to *plants* and *animals.*

645. Respiration is the act of receiving a portion of atmospheric air, or water impregnated with air, into the lungs or respiratory apparatus, by *inspiration,* whence, after a brief interval of time, it is expelled in the act of *expiration.*

646. Respiration is effected by the contact of atmospheric air, or of aerated water, with the circulating fluids in their passage through the innumerable capillaries ramifying on the delicate membranes constituting a respiratory surface.

647. In *plants* this function is performed by the *leaves.*

648. The *products* of respiration in the animal and vegetable kingdoms are essentially different.

649. *Animals rob* the air of its *oxygen*, and *exhale* into it *carbonic acid gas.*

650. *Plants absorb* from the atmosphere, and decompose, *carbonic acid,* fix its carbon, and *restore* the *oxygen* to the air.

651. This is more particularly the case during the *day,* and especially during *sunshine.*

652. During the *night*, and in the *shade*, the leaves of plants *absorb oxygen,* and *give off carbonic acid.*

653. Professor Burnet has referred these phænomena to *respiration* and *digestion.* The former is supposed to be with-

out intermission, and to be attended by the formation and *exhalation* of *carbonic acid gas;* the latter to take place only during their exposure to light, and to consist in the *decomposition* of the carbonic acid of the atmosphere, the *absorption* of the *carbon,* and *exhalation* of the *oxygen.*

654. The fungi and the fig-tree offer exceptions to the general rule. Marcet found that mushrooms converted the oxygen of the air into carbonic acid both during the *day and night.* According to Pepys, the perfectly healthy leaves of the fig-tree evolve oxygen even during the *absence of light.* The Jerusalem artichoke derives its nitrogen *immediately from the atmosphere.*

655. The leaves of plants also withdraw water from the atmosphere.

656. The decomposition of carbonic acid by plants is proportionate to the intensity and duration of the light to which they are exposed. The quantity absorbed is directly as the force of vegetation.

657. Oxygen is not evolved by plants except carbonic acid be present in the air.

658. Aquatic plants decompose the carbonic acid of the air in the water, and give off oxygen during the influence of light. Part of the carbonic acid contained in the waters of the ocean, lakes, and rivers, is doubtless derived from the respiration of fishes, and would accumulate to a noxious extent were it not replaced by the oxygen emitted by the plants. Hence, fish never thrive in waters which are exempt from vegetation.

659. Plants, then, are as indispensably necessary to the existence of animals as are animals to the existence of plants, for these inhale that which animals exhale, and exhale that which animals inhale.

660. Further, animals unceasingly *produce* that which plants

654. Lindley's Botany, 3rd edition, p. 376.
Phil. Trans. 1843, p. 329.

656. Calvert et Ferrand, Ann. Ch. et Ph. Août, 1844.

658. Brande, op. cit. p. 1863.

incessantly *consume,* viz. carbonic acid, water, nitrogen, and oxide of ammonium. What the one gives to the atmosphere the other takes from it. Hence, it has been tritely said that, "in so far as their actual organic elements are concerned, plants and animals are the offsprings of the air."

661. By the reciprocal action, therefore, of plants and animals, the *composition of the atmosphere* is preserved *nearly absolutely unchanged.*

662. Such, however, is the enormous bulk of the atmosphere that, even if there were no restorative or renovating agencies in operation, no less a period than 800,000 years must elapse before the animals living on the surface of the earth could consume the whole of its oxygen.

663. The total weight of the oxygen of the atmosphere has been stated (310) to be equal to 134,000 cubes of copper, one kilometre in the side. Now, supposing the earth to be peopled by 1,000,000,000 men, and its animals to be equivalent to 3,000,000,000 more men, and plants to have ceased from their functions over the entire surface of the earth, it may be shewn that these together would not consume, in the course of a year, a weight of oxygen equal to 16 of these 134,000 cubical kilometres of copper; or, that the oxygen of the atmosphere would not be diminished to any greater extent than $\frac{1}{8000}$th part of its entire weight, during a century; and, further, that no sensible effect would be produced on Volta's eudiometer in a less period than 10,000 years.

664. But were the vegetable kingdom to cease for only one single year to prepare *food* for man and animals, the whole earth would be depopulated; animals would perish of hunger, and organic life would disappear with vegetation.

660. The Chemical and Physiological Balance of Organic Nature, by J. Dumas and J. B. Boussingault. London, 1844, p. 5.

662. Ibid. pp. 19, 20.

De Saussure.

Vide Note 53, p. 15.

664, 665, 666. Dumas and Boussingault, op. cit. pp. 20, 21.

665. The vegetable world is an immense storehouse of carbon, hydrogen, nitrogen, and oxygen, destined for the consumption of the animal world.

666. The atmosphere is the mysterious link which connects the animal with the vegetable, the vegetable with the animal kingdom; in fine, the *atmosphere* is the source whence the vegetable world is nourished. Vegetables and animals, therefore, come from the atmosphere, and return to it again.

667. In *animals* the process of respiration is partly *mechanical,* and partly *chemical.*

668. By the function of respiration the fluids of the living body are oxygenated and decarbonized, and their vital properties renovated.

669. Respiration takes place in the general surface of the skin, or in the mucous lining of the alimentary canal, or in any external or internal organ especially appropriated to it.

670. The *lowest animals* respire by their general cutaneous mucous surface only.

671. In the *more perfect* animals, the external surface is not sufficient for the aeration of the circulating fluids, and hence the necessity for an apparatus which, in a small space, affords the largest possible superficies for contact with the atmosphere.

672. The external skin, or its internal mucous prolongation, is the origin of most of the forms of respiratory organs.

673. A respiratory organ is a determinate portion of external membrane destined to effect certain chemical changes in the air, or in water impregnated with air, which comes in contact with it, developed, by multicapsular foldings, within a small space, into a great extent of surface.

a. The respiring surface may be obtained by the development of a system of tracheal tubes, ramified to extreme fineness, and spread through the most minute portions of all the organs of the body—the tracheal system of *insects.*

673. Müller's Physiology, by Baly, vol. i. p. 314.

b. The respiratory organs may be situated towards the exterior of the body, in the form of lamellated, ramified, pectinated, tufted, ciliated, or pinnated processes, called *branchiæ*, or gills—the respiratory system of *fishes*.

c. Or, the respiratory organs may be situated towards the interior of the body in the form of ramified tubes, or sacculated cavities, called lungs—the respiratory system of *reptiles*, *birds*, and *mammalia*.

674. The respiratory organs of the *infusoria* consist of delicate *cilia*. In the *polypifera* the whole surface serves the function of respiration. The tintacula of the *alcyonella* supply the office of branchiæ. In the *holothuria* the respiratory apparatus assumes the form of an arborescent tube, with terminal cellules, the water entering the general cavity of the peritoneum through the cloacal aperture. The upper surface of the body of the *asterias* is covered with innumerable minute transparent colourless fleshy tubes, through which water has access into the interior cavity of the body. The *annelida* possess tufted branchiæ of an arborescent form, and, sometimes, membranous sacculi, or internal air-cells. Of the *mollusca*, some breathe in water by means of branchiæ; others in the air, by means of lungs. The organs of respiration of the *crustacea* are branchiæ, attached either to the feet or to the abdominal surface of the body. In the terrestrial *onisci*, which respire air, the branchiæ are simple hollow leaf-like appendages.

675. The respiration of the *arachnida* is both pulmonary and tracheary. The first consists of sacculated cavities on the under surface of the abdomen, opening by means of stigmata; the second of tracheal tubes, ramifying through all parts of the body. *All insects* have a system of ramifying tracheæ; for the most part, the respiration is aerial. In the *orthoptera* there are distinct respiratory movements, alternate dilatation and con-

674. Outlines of Comparative Anatomy, by R. E. Grant, M.D. London, 1840.
A General Outline of the Animal Kingdom, by T. Rymer Jones, 1841.
Müller's Physiology, by Baly.

traction of the abdomen. *Fishes* breathe by branchiæ, the surface of which offers the greatest possible extent for the contact of aerated water. In the common ray, the branchiæ or gills have a surface of 2,250 square inches. The *amphibia* respire, while young, by means of branchiæ, to which, in many, pulmonic cavities are subsequently superadded. The lungs of *reptiles* are capacious sacs, subdivided into numerous polygonal cells by internal membranous septa. The lungs of *birds* are spongy masses of extreme vascularity, firmly bound down to the dorsal aspect of the thorax; the main trunks of the bronchial tubes perforate the pulmonary organs, and open by wide mouths into large and numerous thoracico-abdominal cells, which communicate freely with the cavities of the bones.

In the *mammalia* the structure of the lungs is of a higher order.

676. The respiratory organs of *man* consist of a *trachea* (*τραχεια αρτηρια*), or windpipe, and two spongy and highly vascular organs, *lungs* (pulmones), occupying the greater part of the cavity of the thorax.

677. The lungs are situated in the lateral parts of the thorax, separated from each other by the mediastina, heart, and large blood vessels, but connected to each other by the bronchi and pulmonary vessels.

678. The lungs have the form of an irregular cone. The base, which is broad and concave, rests upon the convex surface of the diaphragm. The apex, which is rounded, reaches to the level of the first rib; and, in those whose chests are narrow, sometimes extends a little higher. Their inner or mesial surfaces, which are in contact with the pericardium, are much flattened, or even concave.

679. The right lung is divided into three lobes; the left into two.

680. The *volume* of the lungs always bears a due relation to the capacity of the cavity of the chest. Ever in contact

with the internal surface of its walls, the lungs follow all its movements, dilate and contract with it, and adapt themselves accurately to all its varying dimensions.

681. The trachea, opposite to the third dorsal vertebra, bifurcates into two smaller tubes, the right and left bronchus, one for each lung, which they enter at the root. The bronchi divide and subdivide into a vast series of minute branches and delicate extremities, resembling in each lung an inverted, hollow, leafless tree. Each more minute and remote ramification forming a *lobular bronchial tube*, enters a distinct *pulmonary lobule*, within which it undergoes still further division, and ultimately terminates in a small distinct polyhedral *cell*, or *air-vesicle*, of which it is said there are six hundred millions.

682. The entire extent of the interior surface of the air-tubes and pulmonary cells has been estimated, by Keil and Hales, at upwards of 21,000 square inches; and by Lieberkuhn, at 1,400 square feet, or 201,600 square inches.

683. The internal surface of the trachea and bronchia is lined by a mucous membrane, and is provided with a ciliated epithelium: that of the terminal bronchial tubes and air-cells consists of an exceedingly fine, delicate, and transparent membrane, covered by a stratum of squamous epithelium, which, in the latter, by a doubling inwards of itself, forms the intervening septa.

684. Lymphatics, nerves, and a small artery, with its accompanying vein, are distributed to each air-cell, forming around it a delicate and dense capillary net-work, which is spread beneath the thin transparent mucous membrane of both the terminal and lateral air-cells.

685. The meshes of the net-work are scarcely larger than the vessels themselves, the smallest of which only measures from $\frac{1}{2540}$ to $\frac{1}{3000}$ inch. The coats of the capillaries are excessively

681. Elements of Anatomy, by Jones Quain, M.D. Sixth Edit. London, 1856, vol. iii. pp. 281, 283.

682. Schultz, System der Cirkulation, p. 288.

thin, and thus more readily admit of the free exhalation and absorption of which the pulmonary cells are the seat.

686. The structure of the lungs, therefore, is *bronchial*, *lobulated*, *vascular*, *nervous*, *lymphatic*, and *areolar*.

687. The *bronchial* portion consists of the ramifications of the bronchia: the *lobulated*, of innumerable air-cells, invested by areolar tissue, and opening into the finest terminations of the *lobular bronchial tubes:* the *vascular*, of the pulmonary and bronchial arteries and veins; of these, the pulmonary *arteries* convey the *carbonized* blood from the right ventricle of the heart to the diaphanous walls of the air-cells for aeration, whence the *oxygenized* blood is returned by the pulmonary *veins* to the left auricle of the heart; the bronchial arteries carry blood for the nutrition of the lungs, which is returned by the bronchial veins to the vena azygos; the mucous secretion found in the air-tubes and pulmonary cells is probably derived from the bronchial arteries distributed to their surface: the *nervous*, of branches from the anterior and posterior pulmonary plexuses, which are chiefly formed by branches from the pneumo-gastric and great intercostal nerves: the *lymphatic*, of superficial and deep-seated absorbents, and bronchial glands: and the *areolar*, of the interlobular areolar tissue which connects the whole together.

688. The lungs are the least dense organs of the animal organism, and, according to Dr. Reid and Mr. Hutchinson, weigh, in the male, upon an average, only one thirty-seventh, and, in the female, only one forty-third part of the whole body.

689. The *chemical changes* effected in the blood by respiration are under the control of the grey filaments of the great sympathetic nerves and their ganglia.

690. *Respiration, mechanism of.*—Though all the respiratory movements are performed involuntarily, they are, nevertheless, to a certain extent, subject to our own will. We can regulate the commencement of each inspiration, and can shorten or

prolong it. We can, at will, inspire by the diaphragm only, or with the ribs only, or with both at the same time.

691. *Inspiration.*—During *inspiration* the whole thoracic cavity and air-passages *dilate*, the diaphragm *contracts* and becomes more plane, the abdominal muscles relax, and the viscera are pressed down from above, and air rushes into the air-tubes and cells, distending them in proportion to the dilatation of the thorax.

692. In a natural tranquil inspiration the dilatation of the chest is effected almost wholly by the contraction of the diaphragm, and descent of the abdominal viscera, and but slightly by the ribs.

693. In a *deep inspiration,* the ribs elevate and *advance* the *sternum,* whilst the *abdomen recedes.* The descent of the diaphragm is very questionable.

694. The lateral dilatation of the thorax is performed principally by the contraction of the external intercostal, scaleni, levatores costarum, serratus posticus superior, and thoracic muscles generally.

695. *Expiration,* when perfectly natural, is the result of the mere collapse or elastic reaction of the parts recovering their natural state after the dilatations which they undergo in respiration.

696. In *expiration,* the thorax, air-passages, and cells *contract,* the diaphragm *relaxes,* and becomes convex superiorly, and the air is expelled by the air-passages.

697. *Extreme expiration* appears to consist in a general compression, approximation, and lowering of the ribs, and a receding or flattening of the whole anterior part of the body.

698. It is believed that the lungs themselves do not aid in the respiratory movements.

690, 691. Müller's Physiology, by Baly, pp. 359, 360.

693, 697. On the Capacity of the Lungs, and on the Respiratory Functions, by John Hutchinson, Medico-Chirurgical Transactions, vol. xxix. 1846, p. 187.

698. Müller's Physiology, by Baly, p. 361.

699. The breathing of the female is more costal and less abdominal than that of the male.

700. The *muscles of expiration* are the recti, obliqui, and transversales abdominis, which draw down the ribs, and force the abdominal viscera against the relaxed diaphragm, and thus diminish the cavity of the thorax; and the serratus posticus inferior, sacro lumbalis, and longissimus dorsi.

701. The *nerves of respiration* are, 1st, the portio dura of the seventh pair, the respiratory facial nerve of Sir Charles Bell; 2ndly, the superior and inferior, or recurrent, laryngeal, branches of the nervus vagus; 3rdly, spinal nerves, the nervus respiratorius externus of Bell, and the nervus ascessorius of Willis; 4th, the phrenic; 5th, the spinal nerves.

The 1st. governs the motions of the alæ nasi and the muscles of the face; the 2nd. the dilatation and contraction of the glottis; the 3rd. the lateral dilatation of the thorax, the elevation of the shoulder, and contraction of the abdominal muscles; the 4th. the contraction of the diaphragm; and the 5th. the contraction of the abdominal muscles.

702. The medulla oblongata is the source of all the nervous influence of the respiratory movements. Its injury or destruction utterly annihilates them. Hence the medulla oblongata is the most mortal part of the body.

703. The continuance of the involuntary respiratory movements is wholly dependent on the integrity of the medulla oblongata; but their regular succession is exceedingly wonderful, and equally difficult of explanation.

704. The *sympathetic affections* of the respiratory muscles are *coughing*, *sneezing*, *yawning*, *hiccough*, *laughing*, and *crying*.

Coughing is the consequence of irritation of the nervus vagus in the larynx, trachea, and lungs being communicated to the medulla oblongata. *Sneezing* is a sudden and

702. Müller's Physiology, by Baly, p. 364.
703. Ibid. p. 370.
704. Ibid. p. 369.

violent contraction of the muscles of expiration, the air-passages having been previously closed at the fauces. The diaphragm takes no part in sneezing. *Yawning* consists of a deep and slow inspiration and expiration, with simultaneous action of the respiratory muscles of the face. *Hiccough* is really an affection of the diaphragm, an abrupt inspiration performed by the diaphragm alone, sometimes occurring whilst the glottis is closed. *Laughing* and *crying* are also accompanied with affections of the respiratory nerves of the face and trunk.

705. The *latitude of movement* performed by the walls and floor of the chest may be divided into—

1. An ordinary or quiescent state.
2. Extreme expansion. Great inspiration.
3. Extreme contraction. Forced expiration.

706. The quantity of air which passes through the lungs during *ordinary* respiration, "*breathing air*," is variously estimated, by different writers, at from 3 to 100 cubic inches. According to Matteucci 20 cubic inches, or rather more than half a pint, are taken into the lungs at each inspiration. Richerand fixes the quantity at 30 cubic inches; Haller, Thomson, and Menzies at 40 cubic inches. From 16 to 20 inches may, however, be considered a nearer approximation to the truth.

707. The lungs cannot be completely emptied of air by the most violent muscular effort. That portion which remains in the lungs after the strongest expiration, and over which we have *not any control*, is termed "*residual air*," and is calculated at from 40 to 260 cubic inches. Davy estimates it at 41, Goodwyn at 109, and Menzies at 179 cubic inches.

708. A further portion of air always remains in the lungs after gentle or *ordinary expiration*, which *may* be thrown out

706. Lectures on the Physical Phenomena of Living Beings, by Carlo Matteucci, translated by Jonathan Pereira, M.D. London, 1847, p. 120.

707, *et seq*. On the Capacity of the Lungs, and on the Respiratory Functions, by John Hutchinson, Medico-Chirurgical Transactions, vol. xxix, 1846, p. 137, *et seq*.

at will; to this the name of "*reserve air*" has been applied. This has been estimated to range from 77 to 170 cubic inches. Davy calculates it at 108 cubic inches.

709. To that portion of air which can, by the deepest possible inspiration, be taken into the lungs, the term "*complemental air*" has been given. Davy estimates this at 119 cubic inches; Kite at 200; it may therefore be stated to be from 119 to 200 cubic inches.

710. The term *vital capacity* of the chest, has been applied to the greatest voluntary expiration following the deepest inspiration, and is expressive of the "*complemental,*" "*breathing,*" and "*reserve airs,*" *conjointly.* This has been calculated at from 100 to 300 cubic inches. The average is about 225 inches.

711. The term "*absolute capacity*" is *something more* than "*vital capacity,*" and includes the "*residual air.*"

712. If to the "*vital capacity,*" 225 cubic inches, be added the average "*residual air,*" 150 cubic inches, the average "*absolute capacity*" of an adult male of ordinary height will be 375 cubic inches.

713. The "*vital capacity*" may be considered as a constant quantity, but modified or disturbed by *stature, weight, age,* and *disease.*

714. *Stature* bears the most constant and marked relation to the vital capacity. The height being given, the vital capacity may be predicated almost unerringly.

715. The vital capacity increases with the height, in arithmetical progression, from 5 ft. to 6 ft.

716. Below, and up to 5 ft. the mean vital capacity is 174 cubic inches.

717. For *every inch* of height from 5 ft. to 6 ft. and upwards, the vital capacity is increased *eight* cubic inches.

718. The "vital capacity," though corresponding so accurately with the stature, is neither regulated by the size nor depth, the breadth nor length of the chest.

719. The depth of the chest does not increase with the height.

720. Height governs the amount of air expelled from the chest.

721. The vital capacity is governed by the *mobility*, or range of movement, of the boundaries of the thorax.

722. The *mobility* of an ordinary man's chest is about *three* inches. It may be found by passing a tape measure round the chest over the region of the nipples, and directing the individual to inspire deeply, and expire forcibly. The difference between the two measurements will be the "*mobility*."

723. The expiratory power is, on an average, one-third stronger than the inspiratory power.

724. The inspiratory power is greatest at 5 ft. 7 in. and 5 ft. 8 in. As the stature *increases* beyond this the power gradually *decreases*.

725. The inspiratory power is a surer test of the *vis vitæ* than the expiratory.

726. The difference between the inspiratory and expiratory powers is chiefly due to the elasticity of the ribs.

727. The voluntary and elastic powers are *combined* in expiration, but *antagonise each other* in *inspiration*.

728. *Weight.*—The weight increases with, and may be calculated from, the height.

729. At 5 ft. 1 inch, or 61 inches of stature, the weight is 120 lbs.

	ft. in.		ft. in.		lbs.
For *every inch* of stature from	5 1	to	5 4	the weight increases	6·2
" "	5 4	"	5 7	"	3·3
" "	5 7	"	6 0	"	6·5

730. At 5 feet 6 inches the vital capacity *decreases* 1 cubic inch per lb. between 11½ and 14 stone. At other heights a man must exceed his average weight by 7 per cent. before his vital capacity will be affected. *Beyond this* it will be *diminished* one cubic inch per pound for the next 35 pounds.

731. *Age.*—Up to 35 years the vital capacity *increases* with the age; from 35 to 65 years it *decreases* 1·43 cubic inch per year.

732. *Disease.*—In *phthisis pulmonalis* the vital capacity diminishes from 10 (*the early stage*), to 70 per cent. (*the advanced stage*).

733. The vital capacity of the lungs is measured by the *spirometer* (from σπαίρω, to breathe, and μετρον, a *measure*), the invention of Mr. Hutchinson.

This ingenious yet simple instrument is fully described in Mr. Hutchinson's able and interesting paper, which will amply repay an attentive perusal.

734. We must now pass on to the consideration of the *circulation of the blood,* and first of the *heart,* the centre of the circulating system.

735. The *heart* is a hollow muscle, of an irregular pyramidal shape, placed between the concave surfaces of the two lungs, and enclosed in its proper investing membrane, the *pericardium.*

736. The heart is a double organ, consisting, on either half, of an *auricle* placed superiorly, and of a *ventricle* placed inferiorly, communicating with each other by the auriculo-ventricular opening, both of which are furnished with a valve, called, on the left side the *mitral* or *bicuspid valve*, and on the right side the *tricuspid valve.*

737. The outlets of both the left and right ventricles are also furnished with valves, termed *sigmoid*, or *semilunar.*

738. The valves permit the blood to flow in the direction of the circulation, but prevent its regurgitation.

739. The *left* side of the heart is appropriated to the *systemic,* the greater, or *arterial* circulation; the *right,* to the *pulmonary*, the lesser, or *venous.*

740. The blood is propelled, by a vermicular contraction of the left ventricle, through the arteries to the most remote capillaries of the body, nourishing in its course, and sustaining the vital activity of, all the organs and tissues. It returns by

the veins to the anterior or right auricle, by a peristaltic contraction of which it is driven into the right ventricle, and by this into the pulmonary artery, by the numerous branches of which it is distributed through the minute capillaries of the air-cells (687) to be exposed to atmospheric influence. Upon emerging from the lungs it enters the left or posterior auricle by the four pulmonary veins: by the contraction of this, simultaneously with the right auricle, it is forced into the left ventricle, whence, by the contraction of this synchronously with that of the right side of the heart, it is again propelled into the aorta, to be redistributed throughout the whole arterial system.

741. Hering has calculated that the whole course of the circulation, with some few exceptions, is effected in from 25 to 30 seconds.

742. Reckoning the whole amount of blood (829) in the body at 32 pounds, and, assuming that at each systole the left ventricle projects 1½ ounce of blood, and that the number of the heart's contractions be 74 in the minute, it would require 314 pulsations, or 4 minutes 36½ seconds, to circulate the whole quantity.

743. The circulating system is the channel of communication between the capillaries of the lungs, wherein the blood is prepared by the action of the air for the maintenance of the different functions of life, and the capillaries of the rest of the body, where it is applied to the support of these different functions.

744. The contraction of the heart is called *systole* (from συστελλω, "to contract"); its dilatation, *diastole* (from διαστελλω, "to separate").

745. "The natural sounds of the heart," which are *two*, "are nearly similar to each other: the first occurs with the beat (*systole*) of the heart, the second immediately after. They

741. Treviranus Zeitschrift für Physiologie, 1832, p. 85.

are caused *by the valves,* which, being membranous, are thrown each time they resist the reflux of the blood into a state of sudden tension, which produces sound."

746. "The *first* sound is caused by the tension produced in the shutting of the auriculo-ventricular valves, the *second* by that produced in the shutting of the ventriculo-arterial valves." "No part of the sound depends upon muscular noise, *bruit musculaire.*"

747. "Any flexible solid suddenly brought from a state of relaxation to a state of tension vibrates, and its vibrations are sonorous or not—*i. e.* audible or not—according to its physical structure. At the commencement of the systole of the ventricles their auricular valves are flapped into play; at the instant of their closure the whole substance of the ventricles and the valves are suddenly brought into a state of tension, and then consequently vibrate."

748. Much discussion has taken place, and no small amount of theories and hypotheses been broached, on the subject of the "sounds of the heart." Dr. Walshe tells us that, from the time of Laennec, at least *twenty-nine* theories have been advanced in explanation. By some the sounds are attributed to a "*bruit musculaire,*" though *in health there is no such sound.* Others believe the sounds to be caused by "the motion and collision between the particles of the contained fluids." Dr. O. B. Bellingham considers "the sound to depend on the friction between the blood and the parietes of the arterial orifices;" some, amongst whom Majendie, believe that the sounds are easily explained by "impulsion of solids against solids"—the stroke of the heart's apex against the ribs. It has been shown by Mr. E. L. Bryan that the *apex* of the heart *never touches* the chest-wall, and that the *side* of the

745, 746. Practical Observations on Diseases of the Lungs and Heart, by Archibald Billing, M.D. London, 1852, pp. 8, 11.

747. On the Motions and Rhythm of the Heart and the Causes of its Sounds and Impulse, by E. L. Bryan; Lancet, vol. i. 1832, 1833, p. 486.

heart *never quits it.* Some writers assign *one* cause, some *two*, others *three*, some *four*, and others *seven*, for the sounds of the heart.

The plain, simple, and self-convincing explanation of Dr. Billing recommends itself to one's common sense, and is unquestionably the *true cause* of the "sounds of the heart."

749. Dr. Halford, from an extended series of experiments on anesthæsied donkeys, dogs, and rabbits, has determined and settled this question beyond the possibility of further dispute or discussion.

750. In these experiments the anterior portion of the thorax was removed in order to expose the heart. The two sounds were now distinctly heard. The vena cava inferior was next compressed, just before it enters the heart, by a pair of Liston's bull-dog forceps; the superior cava and pulmonary veins, entering the right auricle, being at the same time compressed between the fingers and thumbs. The action of the heart continued as vigorous as before, although it contained little or no blood after the first contraction. A stethoscope was now applied, but *no sound whatever was heard;* muscular action was going on, but sound was annihilated. Upon the fingers and forceps being removed, and blood admitted to the cavities of the heart, both sounds were restored.

These sounds were destroyed and reproduced at pleasure; and in one or two instances the same heart contracted vigorously for upwards of an hour.

751. "I contend, therefore," continues Dr. Halford, "that the fact of both sounds being destroyed and reproduced by the same means is the greatest proof, *and the first that has ever been given*, that they depend upon the same cause, which is simply the backward current of the blood producing forcible closure and *tension*, first of the auriculo-ventricular (first

749, 750. Experiments and Observations on the Action and Sounds of the Heart, by George Britton Halford, M.D. Bridgnorth, pp. 6, 9.

751. Ibid. p. 11.

sound), and, secondly, of the ventriculo-arterial valves (second sound)."

752. Sounds very similar to the first and second sounds of the heart were produced by Mr. Brakyn, of Dublin, on the heart of a dead ox, by means of air by which the several valves were closed. The tension thus occasioned emitted sounds very closely allied to those effected in the living animal by the impulse of the blood itself.

753. The action of the heart, in point of time, may be thus divided:—Last part or pause $\frac{1}{8}$, first sound and impulse $\frac{1}{2}$, second sound $\frac{1}{4}$, first part or pause $\frac{1}{8}$.

754. The movements of the heart are regulated by the pericardium.

755. The contractions of the heart of an adult man in the middle period of life vary from seventy to seventy-four or five.

756. The frequency of the heart's action gradually diminishes from the commencement to the end of life.

At birth the number of pulsations	in a minute	is from	140	to	130
During the first year	,,	,,	130	to	115
,, second year	,,	,,	115	to	100
,, third year	,,	,,	100	to	90
About the seventh year	,,	,,	90	to	85
,, fourteenth year	,,	,,	85	to	80
In the middle period of life	,,	,,	75	to	70
In old age	,,	,,	65	to	50

In the female the heart beats more frequently than in the male.

757. The pulse is more frequent in the standing than in the sitting position, and in this than in the recumbent posture. In a hundred healthy males of the mean age of 27 years, and in a state of rest, Dr. Guy found the mean number of the pulses to be, standing 79, sitting 70, and lying 67. The frequency of the pulse, when standing or sitting, has been shown to depend on the amount of muscular exertion required to sustain the body in either of these positions.

752. Lancet, 24th November, 1849.

753. Halford, op. cit. p. 15.

754. Ibid. p. 6.

756. Müller's Physiology, by Baly, pp. 183, 184.

757. Guy's Hospital Reports, Nos. vi, vii.

The frequency of the pulse is somewhat diminished during sleep.

758. The pulse may be reduced 50 beats in the minute, and may be rendered irregular, and quite imperceptible, by the long continued action of *cold water* on the surface of the body.

759. A shower or douche bath, delivering per minute from 30 to 40 gallons of water, at 64° or 68°, will occasion the immediate depression and reduction of the pulse to this extent.

760. A shower bath of eight gallons only, at 47°, reduces the *volume*, but does not affect the *frequency* of the pulse. At 74°, or 110°, no perceptible effect is observed.

761. After a meal, and during bodily exertion, the heart's action is accelerated.

762. In a communication, read May 26, 1857, before the Royal Medical and Chirurgical Society of London, Dr. Edward Smith detailed the effects of exercise of various kinds on the pulse and respiration.

—	Number of Respirations per Minute.	Depth of Respirations in Cubic Inches.	Cubic Inches of Air breathed per Minute.	Frequency of Pulse per Minute.
Standing, before exercise . . .	14	43	600	75
Walking upwards of 4 miles per hour .	30	80	2400	130
Carrying 118lbs. at the rate of 3 miles per hour	24·5	90	2141	189
Ascending steps at the rate of 640 yards per hour	22 .	90	1986	114
Working the Tread-wheel for seven periods of a quarter of an hour each, with intervening periods of a like duration	25·5	99·5	2500	161
Sitting, at the end of each intervening period	16·75	50·5	852·5	108·5

758, 759, 760. On the Effect produced on the Circulation by the long-continued Action of Cold Water externally, by H. Bence Jones, M.D. and W. H. Dickinson, Esq. Read April 14, 1857, before the Royal Med..Chir. Society of London.

762. On the Influence of the Labour of the Tread-wheel over Respiration and Pulsation, &c. by Edward Smith, M.D. Proceedings of Royal Med. Chir. Society, 1857, vol. i. No. iii. pp. 101, 102.

763. The frequency of the heart's action increases in a corresponding ratio with the elevation above the sea-level.

764. The question naturally arises, whether does this acceleration of the circulation depend on rarefaction of the atmosphere, or on the exertion and fatigue necessarily attendant upon ascending to any considerable elevation.

765. M. de Saussure, whose constant journeyings among the Alps afforded him the opportunity of forming, and whose scientific attainments enabled him to arrive at, an accurate estimate upon this point, thus expresses himself:

"It is necessary that a determinate quantity of air traverse the lungs in a given time. If the air be doubly rare the inspirations must be doubly frequent, in order that the rarity may be compensated for by the increase of volume. This *forced acceleration* of the respiration is the cause of the increased circulation, and of the fatigue and extreme distress experienced at great elevations."

766. The *steepness of the ascent* is not the sole cause of the fatigue experienced in ascending. The rarity of the air at an elevation of 1,300 or 1,400 toises above the sea-level produces very singular effects. One of these is the extreme rapidity with which the muscular powers are exhausted. "Si l'on persiste à faire des efforts, on est saisi par des palpitations et par des battemens si rapides et si forts dans toutes les artères que l'on tomberoit en défaillance si on l'augmentoit encore en continuant de monter."

"Some are seized, at a certain height, with nausea, vomiting, and even faintings, followed by a sleep of an almost lethargic character."

767. "Some individuals suffer," says M. de Saussure, "when they attain to 800 toises (5114·96 English feet) above the sea-level; others at 1,200 (7672·4 feet), some at 1,500 or

763. Parrot, Froriep. Notizen, 212.

765. Op. cit. tom. iv. p. 207, § 2021.

766. Ibid. tom. i. pp. 402, 403, § 559.

1,600 (9590·5 or 10229·9 feet)." M. de Saussure, in common with the greater part of the inhabitants of the Alpine regions, was not sensibly affected until he had reached to 1,900 toises (12,148 feet = 2·3 miles). Above this elevation those most accustomed to mountain travelling suffer whenever they move quickly.

768. M. Pictet, at an elevation of 1,400 toises above the sea-level, could never take more than *forty* steps without stopping to take breath, and was always seized "d'une espèce d'angoisse, d'un léger mal de cœur et d'un dégoût absolu."

769. "These effects," continues M. de Saussure, "are not to be attributed to the difficulty of breathing, but *au relâchement des vaisseaux produit par la diminution de la force comprimante de l'air.*"

770. M. Bouguer, in his "*Voyage au Pérou,*" says, "we were first inconvenienced by the rarity of the air; some suffered from slight hæmorrhages from the lungs, occasioned doubtless by the atmosphere not being sufficiently dense to assist, by its compression, the blood vessels to return their contents. Several, when we ascended, fainted away and vomited. These symptoms *did not occur when they were on horseback.*"

771. We have seen (56) that, at the sea-level, every point of the surface of our bodies sustains a *pressure* equal to that of a column of mercury 30 inches high, equivalent to a total pressure on the whole surface of 32,400 lbs. At an elevation of 7,500 feet this pressure would be diminished one-fourth = 8,100 lbs.

772. The effects of this diminished pressure, varying in degree in each individual, would be, according to Dr. Spier, "vertigo, headache, dyspnœa, constriction of the chest, palpitation, syncopal tendency, oozing of blood from the mucous

767. Op. cit. tom. iv. p. 210.
768, 769. Ibid. p. 404.
770. Ibid, pp. 36, 37.

surfaces, increased rapidity of the pulse, nausea, and vomiting, intense thirst, febrile tongue, muscular pain, sense of extreme debility in the lower limbs, and general prostration of strength," "results arising," according to the same author, "from a three-fold source: congestions of the deeper portions of the circulatory apparatus, increased 'venosity;' in other words, impurity of the blood, and a loss of equilibrium between the pressure of the external air and that of the gases existing within the intestines."

773. To these may be added faintness, singing in the ears, great acceleration of the respiratory system, and overpowering drowsiness.

774. M de Saussure endeavoured to ascertain by a series of observations the *extent* of the acceleration of the circulation *corresponding to any given altitude.*

775. "After we had remained," he writes, "on the summit of Mont Blanc, 15,662 feet above the sea-level, almost quiet, for four hours, Pierre Balmat's pulse was 98, that of Tetû my servant 112, and my own 100. At Chamounix, 2,040 feet above the level of the Lake of Geneva, our pulses, after repose, were respectively 49, 60, 72."

776. On the summit of Roche Michel, 1,792 toises above the sea, and 783 above the post station of Mont Cenis, the pulses of M. de Saussure's party were 112, 112, 80, 104, 108, and 112; and at the post house, in the same order, 100, 96, 88, 100, 108, and 100, which gives a mean of the pulses, on the summit, of $104\frac{2}{3}$, and at the lower station of $98\frac{2}{3}$.

777. M. de Saussure, therefore, arrives at the conclusion that a fall of the mercurial column of 4 inches 2 lines occasions an acceleration of the heart's action of about 6 pulsations per minute.

778. M. Parrot has calculated this acceleration at 5 beats for the first 1,000 metres (3280·855 feet) of elevation, 7 addi-

775. Ibid. tom. iv. p. 207, § 2021.

776, 777. Ibid. tom. iii. p. 86, § 1280.

tional beats for the next 500 metres, 8 for the next 500, and 5 for every additional 500 metres ; or, on an average, one pulsation for every hundred metres. Of the first thousand metres the heart's action is accelerated only one beat for every 200 metres of elevation.

779. On the other hand, the town of Puno, near Lake Titicaca, in South America, 15° 56′ south lat. 70° 35′ west long. with 15,000 inhabitants, is situated at an elevation of 12,000 feet above the sea-level. The city of Potosi in Bolivia, South America, 19° 40′ south lat. 65° 25′ west long. stands at an elevation of 12,600 feet above the sea, and contains 30,000 inhabitants.

780. These cities, elevated though they be, cannot be classed in the same category with those inhospitable heights—the summit of Mont Blanc, and the Hospice of the Great St. Bernard, both *above the snow line* of their respective latitudes. The climate of these intertropical cities, from elevation, is not tropical, but presents every day the changes incident to the four seasons of the year.

781. The mean annual temperature of latitude 15° 56′ is 80·181°; the elevation of the city of Puno, 12,000 feet, gives a fall of temperature (90) of 40°, which, deducted from the mean temperature of the latitude, gives 40·181° for the mean annual temperature of the city of Puno, 8·181° above freezing point. The height of the curve of congelation, or snow-line, due to this latitude is 14,480 feet, or 2,480 feet *above* the city itself.

782. The mean annual temperature of latitude 19° 40′ is 78·266°; the elevation of the city of Potosi, 12,600 feet above the sea-level, gives a fall of temperature (90) of 42°, which, deducted from the mean temperature of the latitude, gives 36·266° for the mean annual temperature of the city of Potosi, 4·266° above freezing point. The height of the curve of con-

778. Op. cit.

gelation due to this latitude is 13,527 feet, or 927 feet above the city.

783. The capability of these elevated localities of sustaining animal life is mainly due to the purifying influence of vegetation, which, scanty though it be, consisting almost entirely of rushes, grasses, herbage, and green cereals, wheat, rye, and barley, the mean annual temperature not permitting corn to ripen (493), exhales, throughout the entire year, a certain amount of oxygen into, and absorbs an equal amount of carbonic acid gas from, the attenuated atmosphere, and thus contributes to render it more fitted for the respiration of man and animals than it would otherwise be. From the same cause the acceleration of the circulation and respiration *due to the respective altitudes* is doubtless diminished in a proportionate degree. The extreme rarity of the air, however, notwithstanding these advantages, occasions a difficulty of respiration both in man and animals, to which the name of *zarochi* is given.

784. It has been stated that but few of the monks of the Hospice of the Great St. Bernard can resist for any lengthened period the severities of the winter, which impair their health, and compel them to retire, with broken and ruined constitutions, to a lower and more genial clime.

785. The hospice is 7,668 feet above the level of the sea, and 217 feet above the snow-line. If Dr. Parrot's calculation be correct, it will follow that at this elevation the heart's action would be accelerated upwards of 22 beats per minute. The question, therefore, suggests itself whether this accelerated circulation, and consequent quickened respiration, for a series of years, has not much more to do with "impaired health, and broken and ruined constitutions," than the "severities of a winter," the mean annual temperature of which is 32·09°? (94)

786. *Increased* as well as diminished atmospheric pressure invariably *quickens* the *respiration*, and, in some, the circulation; in others the circulation is diminished.

786. Med. Chir. Trans. vol. xxiv. p. 228.

787. Mr. Hutchinson, with five others, descended a mine 1,488 feet deep. The barometer rose 1·54 inch, and the thermometer 10 degrees. The *respiration* of the whole party was *accelerated* about one-eighth. In half the *circulation* was *diminished;* in one *no alteration* occurred; in the other two it was *considerably quickened.*

788. Nature has not made man for those elevated regions, and their attenuated atmosphere, nor for these lower depths and denser air.

The Blood.

789. The blood is that vital fluid which circulates throughout the living frame, and supplies it with materials for the formation, development, and nutrition of all its parts, and with matter and power for the maintenance and purposes of life. It removes, by the excretion of special organs, the effete, decomposed materials from the various tissues of the body, and receives its supply of new nutrient matter from the *chyle* of the lymphatic vessels.

790. In the *vertebrata* it is warm and of a red colour; *florid,* and approaching to *scarlet,* in the arteries, and *deep purple* in the veins. In the *invertebrata,* it is for the most part cold and *white.* It is *sky-blue* in the *Helix pomatia, green* in the *orthoptera,* and *yellow* in the silkworm.

791. *Blood, composition of.*—The blood consists of a transparent, nearly colourless, fluid, the "liquor sanguinis," or "plasma," in which are dissolved various salts, albumen, fibrin, and fat, and in which are suspended myriads of blood-corpuscles, lymph—or chyle,—and sometimes oil-globules, and certain smaller particles, termed molecules.

792. The *serum* constitutes from two-thirds to three-fourths

790. Animal Chemistry with reference to the Physiology and Pathology of Man, by Dr. J. Franz Simon, translated and edited by George E. Day, M.A. and L.M. Cantab. London, 1845, vol. i. p. 101.

791. Ibid. p. 102.

of the blood. Its specific gravity varies from 1·027 to 1·030 at 50° of Fahrenheit's scale.

793. The real nature of the blood corpuscles would still appear to be enveloped in some little uncertainty. The most careful observers differ as to their general structure, some affirming, and others denying, the existence of a nucleus.

794. To the use of imperfect microscopic instruments, and to the dilution of the blood with water, may doubtless be attributed the discrepancies which have arisen with regard to the physical characters of the red particles of the blood.

795. The blood corpuscles in man, and in most mammalia, are circular and flattened—*discs*—with rounded edges and a central depression on each surface, the depth of which varies according to the amount of the contents of each globule. Their structure, which is homogeneous, and more dense externally than internally, consists chiefly of the proteine compound *globuline*. The blood corpuscles are endowed with great plastic properties, and are the seat of, and contain, the *hæmatine*, or colouring matter of the blood.

796. Hassall has estimated their *average* size at $\frac{1}{3500}$th, their *minimum* dimensions at $\frac{1}{4545}$th, and their *maximum* at $\frac{1}{3279}$th of an inch. Hewson has calculated their diameter to be from $\frac{1}{4013}$th to $\frac{1}{2637}$th of an inch, and their thickness about $\frac{1}{4}$ or $\frac{1}{5}$ of their diameter. According to Brande, they vary from $\frac{1}{6000}$th to $\frac{1}{4000}$th of an inch.

797. In the embryo the central depressions are wanting, and the blood corpuscles are therefore simply lenticular.

798. The blood corpuscles, according to Hewson, Müller, Schultz, Reichert, Prevost, Dumas, Gerber, Mandl, Barry, Wagner, Rees, Pereira, Lane, Griffiths, and Addison, consist

795. The Microscopic Anatomy of the Human Body, by A. H. Hassall, M.B. London, 1849, pp. 25, 31.

796. Ibid. p. 27.

797. Ibid. p. 25.

798. Ibid. p. 30, note.

of a *red capsule*, shell, envelope, or involucre, composed of an albuminous substance, called *globuline*, inclosing a colourless *nucleus* of a spherical form, $\frac{1}{5000}$th part of an inch in diameter, or about one-fourth or one-fifth of the diameter of the corpuscle, and of an intermediate *red colouring matter*, called *hæmatine*, or *hæmatosine*.

799. The existence of a nucleus is denied by Hassall, Majendie, Hodgkin, Liston, Young, Quekett, Gulliver, Lambotte, Owen, and Donné. "The deep central depression on both surfaces of the blood disc," says Hassall, "together with its little thickness, almost precludes the possibility of the presence of a nucleus."

800. Della Torre supposed each disc to have a central perforation, and an annular form.

801. The blood disc is not a permanent structure, but one which is perpetually subject to destruction and renewal.

802. A continuous formation or reproduction of blood corpuscles is imperatively necessary to compensate for the consumption demanded for the exercise of the vital functions, and for the waste sustained in respiration, in the excretion of urine, abounding in urea (nitrogen and carbon), in the formation of bile, in the cutaneous excretion, in mucous and other discharges, and in the elimination of all effete matter.

803. Hewson is of opinion that the blood corpuscles are formed in the *spleen* from lymph granules. Schultz considers they are generated in the *lymphatic glands*, and that they receive their "coloured capsule" during the process of respiration. From the more accurate investigations, however, of Hassall, it would appear that they are *first met with in the chyle*.

804. "The red corpuscles are—first, carriers of oxygen from the lungs to all parts of the system, and, secondly, are vehicles for the conveyance of carbon back again to the lungs." (883, 886.)

799. The Microscopic Anatomy of the Human Body, by A. H. Hassall, M.B. London, 1849, p. 30, note.

805. The proportion of the red globules may be regarded as a measure of the vital energy. They have been estimated by MM. Andral and Gavarret at 127 in every thousand parts of the vital fluid. In plethora they amount to 154, and in anæmia only to 100.

806. According to Lecanu, the blood corpuscles consist of—

Fibrin	2·9480
Hæmatosine	2·2700
Albumin	125·6273
	130·8453

807. The *white globules*, or *lymph corpuscles*, are far less numerous than the red, from which they differ in size, colour, form, structure, properties, and use.

808. Their average *size* is $\frac{1}{2370}$th of an inch; their *form*, *globular;* and their *structure*, *granular* throughout, and *nucleated.* Their movements in the living capillaries are infinitely *slower* than that of the red corpuscles; and whilst these circulate *rapidly* in the centre or axis of the containing vessel, the former range themselves on the outsides of the current, moving *slowly* onwards, frequently adhering to the walls or sides of the vessels.

809. It would therefore appear that the office of the red corpuscles is one of distribution, and that that of the white globules is intimately associated with nutrition, and the building up and repair of tissues, probably with secretion.

810. Mr. Addison is of opinion that the *white globules* are "the foundations of the tissues and the special secreting cells, the link between the blood and the more solid structures, the unity from which the pluralities arise."

811. In inflammatory affections, especially in such as are attended with suppuration, in critical abscesses and discharges,

807. Hassall, p. 39. 808. Ibid. pp. 39, 43.
809. Ibid. p. 44. 810. Ibid. p. 47.

and wherever nutrition is impeded, the colourless corpuscles accumulate in the vessels in increased quantities.

812. Müller believes the white corpuscles to be identical with the granular corpuscles observed in the lymphatic fluid, an opinion in which Hassall concurs.

813. Donné promulgates the idea that the white globules become ultimately converted into red corpuscles. Hassall, on the contrary, maintains that the white and red corpuscles are totally distinct from each other in origin, form, structure, chemical composition, and in function.

814. Were the white globule to be transformed into the red corpuscle, it is just possible that both nutrition and secretion would be retarded, if not totally suspended; and further, as a consequence of the increase in the number of red corpuscles arising out of such transmutation, a greater consumption of oxygen would take place in, and a larger amount of carbonic acid would be eliminated from, the lungs in respiration, and a corresponding increased amount of animal heat would be developed, the combined result of which would contribute in no small degree to a further wasting of the tissues of the body, already starved and attenuated from deficient nutrition.

815. The *molecules* or *granules* of the blood are very abundant and exceedingly minute, rarely exceeding the $\frac{1}{30000}$th of an inch in diameter. The white globules are supposed to be developed out of the molecules by their union or aggregation.

816. During life the red corpuscles have an attraction for each other, but no affinity for the white globules, which, on the contrary, have an attraction for the walls of the vessels through which they circulate. After death, however, and in blood drawn from the living animal, this repulsive property between the blood discs and white globules ceases, and they readily cohere. This cohesion is termed the *coagulation* of the blood.

811. Hassall, p. 49. 812. Ibid. p. 53.
813. Ibid. p. 56. 815. Ibid. p. 64.
816. Ibid. p. 44.

817. The coagulum gradually separates into a pale straw-coloured or greenish-yellow liquid, *serum*, and a soft clot, *crassamentum*.

818. In venous blood the clot is to the serum as 65 to 34.

819. The coagulation of the blood is prevented by all substances which dissolve fibrin, such as potassa, soda, and their carbonates: it is retarded by various salts, by sugar, by æther, and by bile; and is accelerated by mineral and vegetable acids. Quain, on the contrary, says, acids delay or prevent coagulation.

820. The *inhalation of æther* is supposed to distend and rupture the corpuscles, and to suspend the elimination of fibrin, the consequences of which are an imperfect and diminished clot, and an increase of the serum. M. Magendie says, "æther renders the blood fluid."

821. In inflammatory disorders, a portion of the colouring matter of blood drawn from a vein subsides to the bottom of the vessel, and leaves the upper surface of the coagulum nearly colourless: this is the *buffy coat* of the blood, and is supposed to be nearly pure fibrin, and identical with that part of the blood termed *coagulable lymph*. The buffy coat, according to Mülder, is an *oxide of proteine*, or a combination of fibrin and oxygen.

822. It has been asked, why does the blood remain fluid whilst circulating in living vessels, and why, on the other hand, does it coagulate in hæmorrhage to plug up the bleeding vessel, in the ligatured artery, and when abstracted from the circulation?

823. Until very recently the cause of the coagulation of the blood had remained unexplained. It was reserved for Dr. B. W. Richardson to solve this mysterious problem. He has shown, in an Essay to which the Astley Cooper triennial

818. M. Lassaigne, Medical Gazette, p. 526.

819. Op. cit. p. xlv.

821. Chem. Gaz. March, 1844.

prize has just been awarded by the Council of the Royal College of Surgeons of England, that *ammonia is a constituent of the blood*, and that on its *presence* the solubility of fibrin, and therefore the *fluidity* of the blood, is dependent; and, conversely, that on its *evolution* or *absence, coagulation* essentially depends.

824. Cessation of the blood's motion *within the body* favours coagulation.

825. Blood taken from a vein during the state of vital depression consequent upon infectious or malarious agents, flows with difficulty, is of a dark colour, and coagulates rapidly; the crassamentum, from a diminution or altered condition of the *fibrin*, is large and soft, and the serum small in quantity in proportion to the clot; all, evidences of the great reduction of the constitutional powers.

826. Human blood has a saline taste, a weak alkaline reaction, and a peculiar mawkish odour.

827. Its *specific gravity* varies from 1·049 to 1·057. According to Nasse, the *average specific gravity* may be fixed at 1·055, and according to Zimmermann at 1·056.

828. Its *temperature* in the healthy body is between 98° and 100° Fahrenheit; its *normal mean temperature*, according to J. Davy, is 98·1°.

829. The *quantity of blood* in a well-formed adult has been variously estimated at from eight to one hundred pounds: the former calculation was by Allen, Mullen, and Abildguard, the latter by Keil. It will probably be nearer the truth to assume that the total mass of blood does not much exceed 32 pounds.

830. Yet it is somewhat extraordinary that these thirty-two pounds, or four gallons, of blood, circulating in the living body

823. On the Cause of the Coagulation of the Blood, with a practical Appendix, by B. W. Richardson, M.D.

827. Brande, op. cit. p. 1763.
Wagner's Handwörterbuch, Article "Blut," vol. i. p. 82.
Hufeland's Journal, 1843.

828. Phil. Trans. 1845, p. 325.

and gushing forth from every cutaneous wound, however small, should appear to be almost entirely lost after death, the arteries being empty, the veins, for the most part, containing but threads of coagula, whilst the serum makes no show.

831. *Blood, analysis of.*—The following are the results of the analysis of the blood by M. Lecanu.

The venous blood of man, in its normal state, he considers to be composed of—

Serum	869
Globules	131
	1000

Or, of—

Water	790·3707
Oxygen	
Nitrogen	
Carbonic acid	
Extractive matters	
Phosphorised fat	
Cholesterin	
Serolin	
Free oleic acid	
Free margaric acid	
Chloride of sodium	
Chloride of potassium	
Chloride of ammonium	10·980
Carbonate of soda	
Carbonate of lime	
Carbonate of magnesia	
Phosphate of soda	
Phosphate of lime	
Phosphate of magnesia	
Sulphate of potassa	
Lactate of soda	
Salts of fixed fatty acids	
Salts of volatile fatty acids	
Yellow colouring matter	
Albumen of the serum	67·8040
Globules	130·8453
	1000·0000

831. Ann. Ch. et Ph. LXVII. p. 54.

832. It may not be altogether irrelevant to the subject under consideration, to allude to the original and important discovery which has within the last few years been made by Professor Claude Bernard, the successor of Majendie, with reference to the functions of the liver. This gentleman has ascertained that the liver in man and mammals *secretes a saccharine matter — glucose* — which is conveyed from the secreting cells by the inter— , intra— , and sub-lobular veins to the venæ cavæ hepaticæ, thence, in the course of the circulation, to the vena cava inferior and right auricle of the heart, and by the pulmonary arteries to the lungs, where it is *burned*, thereby contributing to the sustentation of animal heat.

833. M. Bernard, after repeated experiments, and the most careful investigations, could not detect sugar in any other portion of the circulating system, and he therefore felt himself justified in asserting that sugar is a normal product of the liver, and that the saccharine matter, so secreted, cannot be detected *in health* in any secretion, vessel, organ, or tissue of the body, other than in the blood of the veins above mentioned, and in the substance of the liver itself.

834. M. Colin, of the Veterinary School of Alfort, near Paris, and, subsequently, M. Bérard, Professor of Physiology at the Faculty of Medicine of Paris, affirm that they have succeeded in obtaining sugar from the *chyle* of the larger ruminants fed exclusively on animal substances, thus shewing that sugar is *not secreted exclusively* by the liver. M. Fiquier, Assistant Professor at the School of Pharmacy of Paris, adds his testimony against the views advanced by M. Bernard.

835. On the other hand, the experiments of M. Lehmann, of Leipzig, corroborate M. Bernard's opinions.

836. In order, however, to place the question beyond all doubt, the Académie de Médecine of Paris appointed a Com-

832. Nouvelle fonction de Foie, consideré comme organe producteur de matière Sucrée chéz l'Homme et les Animaux. Par M. Claude Bernard. Paris, 1853.

mission to investigate this important matter. The Commission on concluding their investigations presented a report fully confirming all M. Bernard's original statements.

837. But, even admitting, for the sake of argument merely, that sugar has been found in the chyle, this neither invalidates nor detracts from the importance of M. Bernard's discovery that the liver secretes, separates, or eliminates a vegetable substance, *glucose*, from animal matter alone, or from both combined; neither does it disprove his statement that the substance so produced assists, by its combustion in the lungs, in sustaining animal heat. It might, if satisfactorily established, tend to shew that even glucose may have its antecedents.

838. Apart, however, from the interest which attaches to this discovery in a physiological point of view, it originates questions of the gravest import both to the pathologist and to the physician.

839. If the quantity of saccharine matter secreted or separated be not entirely burned in the lungs, the surplus will circulate in the system, to be eliminated by the kidneys as diabetic urine.

840. The question therefore arises, whether, in seeking for the cause of diabetes, we should not look to impaired, defective, or embarrassed respiration, the rather than to a faulty or perverted action of the assimilating organs, or of the kidneys themselves; and whether, in the treatment of this disorder, we should not suggest such measures as may contribute to the increase, where possible, of the respiratory functions, if these be in defect, and, as a consequence, to a larger consumption of glucose?

841. Sugar has been constantly found in the urine of those whose respiration had become enfeebled by age.

842. Again, if the liver, from disorder or disease, fail, either partly or altogether, in its glucogenic, as is constantly the case with its biliary function, the question may arise whether the saccharine matter, or, rather, that substance circulating with the vital fluid, whence the glucose is derived, separated, or

eliminated, may not be capable of inducing disorders other than diabetes.

Respiration, Chemistry of.

843. Under this division we shall consider the *changes* which the *atmospheric air* and *blood* undergo *during respiration.*

844. *Respirations, number of, per minute.* These are stated by Haller to average 20. Out of 1714 persons, Mr. Hutchinson found 510 to breathe 20 times in the minute. We may therefore consider this as the average number of respirations of a healthy adult man, whose heart beats 80 times in the minute.

845. In the female the respirations and pulse are somewhat more frequent.

846. Respiration is modified by sleep, motion, distension of the stomach, "vital capacity," affections of the mind, &c.

847. *Respiration* should bear a *due relation* to the *frequency of the heart's action.*

Any marked variation between these should be looked upon as symptomatic of disorder or disease of the brain, spinal cord, heart, or respiratory organs.

848. *Air.*—During respiration *oxygen* is *absorbed* from the atmospheric air, and *carbonic acid gas given out.*

It will be remembered (15) that atmospheric air consists of

Oxygen . . .	19·7
Nitrogen . . .	78·8
Aqueous vapour . .	1·4
Carbonic acid . .	·1
	100·0

849. *Expired air* differs very much in composition from the atmospheric air. It is found to have *lost* from 4 to 6 per cent. of its *oxygen*, and to have *acquired* from 3·5 to 5 per cent. of *carbonic acid gas*, in combination with ammonia, and a large proportion of *aqueous vapour* (*pulmonary transpiration*). The

proportion of *nitrogen* contained in expired air varies but little from that of the atmosphere, the quantity lost being very inconsiderable.

850. *Carbonic acid gas.*—Philosophers of all times and of all nations have earnestly endeavoured to solve the problem of how much oxygen is consumed, and how much carbonic acid gas is given off during the process of respiration. The results of their experiments are as varied as the attempts have been numerous.

851. The quantity of air which passes through the lungs at each inspiration has been variously estimated at from 3 to 100 cubic inches (706). The number of respirations per minute has been stated to be from 15 to 26.

852. Assuming that a healthy adult male respires 20 times in a minute (844), and takes into his lungs, at each inspiration, 20 cubic inches of *air*, he would inspire 400 cubic inches in a minute, 24,000 in an hour, or 576,000 in 24 hours.

853. Assuming, also, that the expired air contains 4 per cent. only of *carbonic acid*, he would evolve 16 cubic inches per minute, 960 per hour, 23,040 in the 24 hours, = 3,529 grains, or 7 oz. 2 drachms 49 grains of *carbon*.

854. Lavoisier and Seguin estimate the quantity of *carbonic acid* given off by the lungs of an adult man in 24 hours at 14,930 cubic inches; Davy at 31,680; Allen and Pepys at 39,600.

855. Berzelius thinks there must be some error in the two last estimates, as it would require 6½ lbs. of solid food daily to make up the quantity of *carbon* (10 oz. 53 grs., and 10 oz. 5 dr. 48 gr.) said to be evolved.

856. Dumas is of opinion that "two drachms and a half of

849. Richardson, op. cit.

Researches Chemical and Philosophical, chiefly concerning Nitrous Oxide, and its Respiration, by Sir Humphry Davy, Bart. LL.D. 1800, p. 448.

Despretz, Ann. Ch. et Ph. xxvi. p. 337.

854. Animal Chemistry, or Organic Chemistry, in its applications to Physiology and Pathology, by Justus Liebig, M.D. Edited by William Gregory, M.D. London, 1842, p. 283

carbon per hour, or 7 ounces and a half in 24 hours, is probably as near an approximation to the truth as can be made in regard to the generality of men in adult age." He maintains that the consumption of 11¼ ounces, as stated by some former observers, must be the exception, and applicable only to individuals of great stature, of very ample chests (of great "vital capacity"), and who eat largely.

857. The importance of the subject, coupled with the question of how much sustenance for man in the shape of food may be held sufficient to compensate for the carbon separated by the lungs alone, irrespective of that exhaled by the skin, eliminated by the kidneys, or carried off by the intestinal canal, induced MM. Andral and Gavarret to institute a series of experiments on a very extended scale, of which the following are the results:—

858. The quantity of carbonic acid exhaled by the lungs in a given time, from eight years to extreme old age, varies by reason of age (irrespective of weight or stature), sex, and constitution.

859. At every age, from eight years upwards, the exhalation of carbonic acid from the lungs is greater in males than in females.

860. In the *male* the quantity exhaled increases gradually and constantly from the age of 8 to 30 years; from 30 to 40 it is stationary, or rather tends to diminish; from 40 to 50 this tendency is more marked; and from 50 to extreme old age the amount is gradually reduced until it declines to that of the boy of ten years.

861. In the *female* the amount given off from the age of eight years to *the period of puberty* continually increases. But upon the appearance of the catamenia it experiences *no further increase*, except during pregnancy, and *temporary interruptions*

856. Op. cit. p. 92.

857. Ann. Ch. et. Ph. Juin, 1843.

858, 859, 860, 861. Dumas and Boussingault, op. cit. p. 96 to 105.

of the periods, until the final cessation of menstruation, when an enlarged amount is *immediately* exhaled. As years roll on the quantity lessens, and observes the same laws which govern the male.

862. An unimpregnated female, in perfect health, exhales 98·77 grains of carbon per hour; during pregnancy this amounts, on an average, to 123 grains. After the cessation of the catamenia the quantity exhaled, between 40 and 50 years of age, amounts to 129·64 grains; between 50 and 60, this falls to 112; between 60 and 80, to 104·75, a quantity, nevertheless, higher than in women quite regular, and 25 years of age. At 82 the exhaled carbon amounts to no more than 92·5 grains, a quantity very nearly corresponding with that given off by the male of 102.

		years.		grains.		
863. A male	at . .	8	burns	77·17	of carbon	per hour.
,,	,,	15	,,	134·26	,,	,,
,,	,,	16	,,	166·66	,,	,,
,,	from	18 to 20	,,	175·94	,,	,,
,,	,,	20 to 40	,,	188·29	,,	,,
,,	,,	40 to 60	,,	155·88	,,	,,
,,	,,	60 to 80	,,	95·69	,,	,,
,,	at	102	,,	92·33	,,	,,

864. From these experiments it would appear that the average amount of *carbon* exhaled from the lungs of the male, from the age of 15 to 80 years, is 152 grains per hour, or 3,648 grains in the 24 hours = 7 ounces, 4 dr. 48 grains (856).

865. Drs. Prout and Scharling ascertained that the quantity of carbonic acid given off by the lungs varies considerably at different periods of the day and night, and under certain other conditions and circumstances. They found it at its maxi-

862, 863. Dumas and Boussingault, op. cit. p. 96 to 105.

mum after meals and violent exercise, and about noon; and at its minimum about midnight. They also estimated the quantity expired during sleep at one-fifth less than that given off during the waking hours. This, however, has been shown to be incorrect. The diminution does *not depend on sleep,* for sleep, as sleep, *increases* the amount of carbonic acid gas expired, but, upon the *absence of light* (290). A man sleeping will expire more carbonic acid than if he lie quietly awake under precisely similar conditions of light, temperature, &c. Moleschott has shown that in bright sunlight as much as one-fifth more carbonic acid is expired than in feeble light.

866. Hunger, rest, fermented liquors, vegetable diet, and ptyalism, *diminish* the quantity evolved. Mental tranquillity, moderate exercise, and low atmospheric pressure, *increase* the amount exhaled.

867. In accelerated respiration, the aggregate amount of carbonic acid evolved in any given space of time, will be in the direct ratio of the number of expirations, though the quantity given off at each expiration will be below the usual average. Thus, Vierordt found that with 6 respirations in the minute, the entire quantity of carbonic acid exhaled amounted to 11 cubic inches, with 12 respirations to 25·3 cubic inches, and with 48 respirations to 44·5 cubic inches; whilst, in the first case, the expired air contained 5·7 per cent., in the second 4·1 per cent., and in the last only 2·9 per cent. of carbonic acid.

868. In a communication to the British Association it was stated, by Dr. Macgregor, that in the early stage of eruptive fevers, and in chronic skin diseases, the quantity of carbonic acid exhaled from the lungs is increased; in small-pox it amounts to six or eight per cent, in measles and scarlet fever to four or five per cent., and in ichthyosis has reached to 7·2 per

865. Bridgewater Treatise.
Ann. der Pharm. xlv. p. 214.
Ann. Ch. et Ph. 3ème Sér. viii. p. 478.

cent. In diabetes there is no departure from the healthy standard. In typhus fever the quantity, according to Dr. Malcolm, is diminished.

869. *Ammonia.*—Dr. Richardson has ascertained that ammonia in combination with carbonic acid gas is a constant constituent of expired air.

870. *Blood.*—The change which the blood undergoes in respiration is almost entirely confined to the red corpuscles. These, which represent in their independent act of metamorphosis the real vitality of the blood, and from which its fibrin is formed, indispensably require, for their healthy change, a due supply of oxygen.

871. The chemical process which ensues between the air and the blood is carried on through the delicate membranous lining and capillaries of the air cells.

872. The permeation from without to within of living animal tissues, by gases and thin fluids, is termed *endosmosis* (from ενδον, within, and ωσμος, impulsion).

873. The contrary of this, *exosmosis* (from εξ, outwards, and ωσμος, impulsion).

874. In the act of *inspiration* the *oxygen* of the atmosphere permeates the lining membranes of the air cells, *endosmosis*, and is *absorbed* by the blood circulating in the innumerable capillaries which form their vascular reticulation.

875. In the process of *expiration* the *carbonic acid* of the venous blood permeates this lining membrane, *exosmosis*, and is exhaled into the atmosphere.

876. This interchange of gases is, however, more immediately confined to the corpuscles.

877. The cause of the absorption of oxygen by the blood is a *chemical attraction*, by the effect of which a binary compound is formed in the blood.

878. Though the degree of attraction with which the

869. Op. cit.

877. Liebig's Animal Chemistry, p. 265.

oxygen is retained in this compound is very small, this is no reason for assuming that it is only *mechanically absorbed* in it, and *not chemically combined* with it.

879. During the passage of the blood through the lungs the corpuscles lose their *dark, venous colour,* and become of a *bright florid* or *arterial hue.*

880. This change of venous into arterial blood, and its alteration of colour, depend on a separation of carbonic acid gas, which mixes with the air, and on an absorption of oxygen, which combines with certain constituents of the blood.

881. These constituents are the red corpuscles, which contain a *compound of iron saturated with oxygen.*

882. No other constituent of the body contains iron.

883. In the circulation of the arterial blood through the peripheral capillaries, the iron, which is in the state of *peroxide, yields up its oxygen with the utmost facility.*

884. For every volume of oxygen so lost an equal volume of carbonic acid is *produced.*

885. A portion of the oxygen lost in the remote capillaries determines the elaboration of secretions and excretions, the separation of living parts, and their conversion into lifeless compounds. The greater part converts into oxidised compounds the newly-formed substances which no longer form part of the living tissues.

886. In their return towards the heart, the corpuscles, which have lost the oxygen of their contained peroxide of iron, and with it their *bright florid hue,* combine, through their iron, now in the state of protoxide, with carbonic acid, producing *dark venous blood.*

887. The iron of *venous blood* is in a state of *protoxide.*

888. The compounds of protoxide of iron possess the property of *depriving other oxidised compounds* of their *oxygen.*

889. Upon reaching the minute capillaries of the air cells of

878. Familiar Letters on Chemistry, by Justus von Liebig. London, 1851, note, p. 333.

the lungs, the *protoxide* of iron of the corpuscles reabsorbs from the atmospheric air the oxygen it had lost in the peripheral capillaries, and the blood reacquires its florid arterial colour.

890. For every volume of *oxygen* so *absorbed* a corresponding volume of *carbonic acid* is *separated.*

891. According to Valentin and Brunner, 0·9157 vol. of carbonic acid gas is given out for each volume of oxygen which disappears; and as one volume of carbonic acid gas includes one volume of oxygen, it follows that about one-tenth of the latter gas is concerned in the oxidisement of hydrogen.

892. Thus, two processes of oxidisation are going on simultaneously; the one in the *peripheral capillaries,* the other in *those of the air cells of the lungs.* In the latter we have a CHARCOAL *fire* constantly burning, by which the uniform temperature of the lungs is kept up; in the former, a *fire* of ANIMAL and VEGETABLE FUEL, by which the heat of the body is supplied and sustained. The *pulmonary* fire *produces carbonic acid gas;* that of the *peripheral capillaries, carbon.* The *fuel* of the former consists of the *glucose* furnished by the liver, and of the *carbon* prepared in the peripheral capillaries; that of the latter, of the *animal and vegetable matter* supplied by the *food.*

893. The true source of *animal heat,* says Liebig, is to be found in the mutual chemical action of the constituents of the food, and of the oxygen conveyed by the circulation to all parts of the body.

894. The amount of carbon given off by the lungs of an adult man during respiration, 7½ ounces (856, 864), will combine with the same quantity of oxygen as when burned in the open air, and will evolve the same amount of heat, but with this difference, that during respiration the combustion will

891. Löwig, vol. i. p. 683.

892. Billing's First Principles, p. 21.

893. Liebig's Familiar Letters on Chemistry, p. 316.

extend over twenty-four hours, whilst in the latter case it may be effected in as many minutes.

895. If, then, we know how much oxygen an animal consumes in twenty-four hours, and the quantity of carbonic acid and of water produced, the latter being ascertained from the bulk of the oxygen which disappears as gas, it is easy to calculate the whole amount of heat which is produced in respiration.

896. The heat of combustion of pure carbon is, according to Andrews, 7,881 units of heat; that of hydrogen 33,808.

897. The *unit of heat* is the amount of heat which a weight of water, equal to that of the burned fuel, receives when its temperature is raised one degree of the centigrade scale.

898. By the combustion of 1 atom of carbon = 6, and 2 of oxygen = 8 × 2 = 16, carbonic acid is produced. Now as carbonic acid contains $\frac{16}{6}$ times the weight of oxygen it does of carbon, it follows that one part by weight of oxygen, in its conversion into carbonic acid, yields 2,955 units of heat.

899. By the combustion of 1 atom of pure hydrogen = 1, and 1 atom of oxygen = 8, water is formed. Since water contains eight times the weight of oxygen it does of hydrogen, it results that one part by weight of oxygen in its conversion into water yields 4,226 units of heat.

900. The foregoing opinions on the agency of *iron* in the *absorption* of *oxygen*, and the *production* of *carbonic acid* during the respiratory process, are those of Mülder and Liebig. Scherer has recently satisfied himself that he has obtained the colouring matter of the blood *entirely free from iron.* Be this as it may, it cannot be questioned for an instant that iron, internally exhibited, restores the lost colour of the blood.

901. *Pulmonary exhalation.* There is no portion of the human body in which absorption and exhalation proceed with

895, 896, 897, 898, 899. Liebig's Familiar Letters, p. 343.

901, 902. Récherches expérimentales sur l'Exhalation Pulmonaire, par MM. G. Breschet et H. Milne Edwards, pp. 1, 2.

so much rapidity as in the internal surfaces of the bronchia and air cells. One of the conditions on which these depend is the excessive vascularity of the respiratory organs.

902. Every tissue of the animal economy is more or less permeable to fluids. The more vascular is the structure the more highly is it endowed with this property.

903. At each expiration a large quantity of vapour, called "*pulmonary transpiration*," makes its escape.

904. The greater portion of this vapour is supposed to be derived from the chyle in its passage through the lungs.

905. The *aqueous vapour* of the air expired from the lungs is probably exhaled by the innumerable capillaries of the air cells, bronchial and respiratory surfaces.

906. Its quantity is exceedingly variable, and dependent, to a considerable extent, upon the hygrometric condition of the atmosphere, the combustion of hydrogen during respiration, and the amount of fluids taken into the system with the foods, as well as upon the amount of secretion given off by the skin, kidneys, and alimentary canal. It may, however, be approximatively estimated at about 3 grains per minute = 9 oz. in the 24 hours. Menzies calculated it at 2,880 grains = 6 oz., in the 24 hours; Abernethy at 4,320 grains = 9 oz.; Thomson at 9,120 grs. = 19 oz.; Hales at 9,792 grs. = 20 oz. 3 drachms 12 grs.; and Lavoisier at 13,704 grs. = 28 oz. 4 drachms 24 grains, in the 24 hours.

907. The surface of the bronchia and air cells, in addition to the "pulmonary exhalation," permits the escape of gaseous and volatile matters circulating with the blood. Thus, the breath of those who take æther, onions, or spirituous liquors, speedily acquires the odour peculiar to each.

904. Bridgewater Treatise, p. 530.

907. Breschet et H. Milne Edwards, op. cit. p. 1.

CHAPTER IV.

INFECTION, CONTAGION, AND MALARIA.

Infection and Contagion.

908. Much diversity of opinion exists on the subject of *infection* and *contagion.* Very many believe that the most pestilential disorders, typhus, yellow fever, the plague, Asiatic cholera, *et hoc genus omne*, are *not contagious,* that the poison exists in the atmosphere alone, and is not communicable by those labouring under its influence. Others conceive that the atmosphere immediately surrounding those suffering from any *infectious* disorder becomes contaminated by the diffusion of the exhalation from their lungs, and by the effluvia and emanations from their bodies, and that an *infectious,* but *non-contagious,* disorder thus becomes converted into a contagious malady.

909. By common consent, however, most eruptive fevers are considered both *infectious* and *contagious.*

910. By *infection* we understand a contaminated condition of the atmosphere, by pestiferous, miasmatic emanations from the earth's surface, by poisonous gaseous exhalations the product of putrefactive changes of organic or vegetable substances, or by both combined, capable of tainting, polluting, or corrupting the body.

908. An Inquiry into the Origin and Nature of the Yellow Fever, by William Fergusson, M.D. Inspector of Hospitals, and Principal Medical Officer in the Leeward and Windward Islands. Med.-Chir. Trans. vol. viii. p. 118.

911. *Infection* is a local taint of atmosphere originating *without* the body.

912. Disorders produced by malaria, as intermittent, remittent, and yellow fevers, are *not communicable* by the sick to the healthy.

913. By *contagion* we understand the transmission of an *infectious* malady from the sick to the healthy, by pollution of the atmosphere by the effluvia or emanations from, or by the exuviæ of, their bodies; or, by means of *fomites* imbued with the specific poison; or by immediate or mediate contact. In the latter case, the humidity of the atmosphere becomes a medium of contact.

914. It seems to be a general law of animal nature, at least among the *mammalia*, that the accumulation and stagnation of the exhalations of the living body produce disease. The glanders of the horse arise only in stables where a large number of horses are stalled; and the distemper of dogs in kennels. During the American war it was proposed to send live sheep from England across the Atlantic. In a few weeks, in consequence of being crowded on ship board, they all died of a febrile disorder.

915. *Contagion* may therefore be designated a specific virus originating *within* the body.

916. A *contagious fever* or disorder is produced by an *animal poison*, and *not* by *malaria*.

917. "*Animal poisons* effect changes in the blood whereby they themselves are abundantly multiplied or reproduced. The eruptive disease which ensues seems to be the mode provided by nature for the escape or expulsion from the system of this newly-formed matter."

914. Observations on the Comparative Prevalence, Mortality, and Treatment of Different Diseases, by Sir Gilbert Blane, Bart. M.D. Medico-Chir. Trans. vol. iv. p. 95.

917. Lectures on the Principles and Practice of Physic, by Thomas Watson, M.D. London, 1848. 3rd edit. vol. ii. pp. 718, 719.

918. "A substance," says Liebig, "in the act of decomposition, added to a mixed fluid in which its constituents are contained, can reproduce itself in that fluid exactly in the same manner as new yeast is produced when yeast is added to liquids containing gluten."

Thus, the virus of any specific animal poison will effect its own reproduction in the blood of an individual inoculated with it.

919. Liebig shews that similar processes may take place *without* the reproduction of the added poison. In such cases the disorder or disease which results from the transformations that occur in the blood is *not contagious.*

920. In this way certain miasmata produce disorders which are not communicable from individual to individual.

921. *Pyæmia, blood poison,* (from *πυον,* "*pus,*" and *αἷμα,* "*blood,*") is an instance of a poison generated probably by absorption of decomposing pus from an abraded mucous surface, or internal disorder, or from an external wound or disease. Of the former, aphthous ulceration of the tongue and internal fauces, inflammation of the uterine veins after parturition, an abraded urethra from the introduction of a bougie, are examples; and of the latter, amputations, whitlow, &c. The absorbed pus spoils a considerable portion of the ingredients of the blood; these are deposited in the subcutaneous cellular tissue, in the substance of the lungs, in the joints, eyeball, &c., in the form of unhealthy fibrin, which usually softens down into puriform fluid.

922. Could we but bring our minds to believe that, in health, the power of resistance to disorder is superior to the force of the attack thousands of lives would be annually saved. Could we suppose the former to be always represented by 20, and the latter never to exceed 15, we should feel an inward sense of security against, and of power to repel disorder which would give us an almost perfect immunity from attack. But that most depressing of all agents, FEAR, will, at any instant,

suddenly reduce our power of resistance *below* 15, and if this have been already diminished by previous ill health, by debility, by want of food, by cold and damp, by mental depression, by watching, by anxious attendance upon sick relatives or friends, irrespective of advanced age, we speedily fall an easy prey to disorder and pestilence.

923. Hence the value, the advantage, nay, the necessity of preserving, during periods of pestilential invasion, a healthy tone of both the *morale* and the *physique.* If the former can be sustained by a prophylactery, a cabalistic charm, by a camphor bag, or by an amulet of any equally innocent character, are these to be despised and ridiculed; and if the latter can be supported by red meats and fermented liquors, or by quinine and iron, ought those to be doled out with a sparing or niggard hand, or these to be withheld?

924. So well aware were the ancient Greeks and Romans of the influence of *fear* in the production of disease, that during the prevalence of any pestilential fever propitiatory sacrifices were offered to the divinities assigned to preside over fevers, the effect of which was to inspire the people with the most perfect confidence and courage. The Greeks invoked their divinity by the name of Πυρετὸς; the Romans worshipped *Febris.* The latter people erected no less than three temples for her worship; one on the Palatine Mount, another in the Via Longa, and a third in the place of the Monument of Marius.

925. Next after fear in the production of disease rank *depression of spirits, fatigue, scarcity of food,* and *exposure to a hot sun by day, and to the cold dew by night.* As an apt illustration of the combined effects of these, we may contrast the vigorous health of a victorious and pursuing army with the

924. C. Plinii Secundi, Hist. Nat. lib. ii. cap. 7.

925. A Sketch of the Medical History of the First Battalion of the First Regiment of Foot Guards, during the Winter of 1812, 1813, by John Bacot, Med.-Chir. Trans. vol. vii. pp. 375, 376.

sickly and unhealthy condition of the beaten and retiring enemy.

Miasma and Malaria.

926. *Miasma* (from μιαινω, to pollute), a pollution, corruption; *malaria,* a vitiated or contaminated atmosphere.

927. Marsh miasm is a specific poison inducing specific effects upon the human body. These effects are produced in the ratio of the temperature, humidity, and electrical condition of the atmosphere; of the intensity, concentration, and activity of the miasm itself; of the duration of exposure; of the quantity inhaled and absorbed; and of the susceptibility or state of predisposition of those exposed.

928. In its mildest form, and in cold and temperate latitudes, miasmatic emanation gives rise to the ordinary ague, or intermittent fever of Europe; and in countries and intertropical climates, where, *in proportion to the intensity of the temperature* is the *intensity of power* in the miasm evolved, it produces the highest degree of aggravated remittent and ardent continued fevers, yellow fever, plague, or pestilential cholera. (966.)

929. The operation of malaria, when highly concentrated and most deadly, may be almost immediate. Thousands have been struck down, and have, from the potency of the poison, died in a few hours in the stage of collapse, the vital energies being impressed to the extent of subverting the power of reaction. In pestilential cholera patients have been stricken down almost lifeless and have died in a few minutes.

930. "Fever," says Dr. Macculloch, "may be induced within half an hour after exposure to malaria. A single inspiration, or the space of a very few seconds, is amply sufficient for the purpose. In France and Italy instances are recorded

928. Med.-Chir. Trans. vol. viii. p. 130.
930. Op. cit.

of labourers dying instantaneously from merely sitting or lying down on the ground; and of others, who, from looking into a ditch or drain, have been struck dead by that poison which, in a minor degree, would have merely produced a fever."

931. When emanation is less copious or less virulent, or when the poison is freely diluted with atmospheric air, its operation is less sudden, and its effects are much milder.

932. We have already seen that a healthy adult respires 20 times in a minute (844), and takes into his lungs, at each inspiration, 20 cubic inches of air, or 576,000 cubic inches in 24 hours (852); and that this respired air comes in contact, at each inspiration, with 201,600 square inches of mucous surface of air passages and cells (682). Is it, therefore, matter of surprise, that atmospheric air, contaminated by infectious or contagious matter, or poisoned by malarious, miasmatic, or paludal emanations, should exert its baneful influence on the blood, and on the organic nervous system, through the nerves distributed to the enormous superficies with which it comes in contact at each inspiration? The wonder is that any of us escape. Indeed, where the percentage of contamination is large, few do escape. The history of the plagues and pestilences with which this and other countries have been visited during the last few centuries fully bears out this position.

933. Dr. W. Fergusson states that the African and the Creole are, in a great degree, exempt from, and very rarely amenable to, those influences which generate in Europeans intermittent, remittent, or yellow fever.

934. The precise nature of marsh effluvia has not yet been determined, though the most able analytical chemists and microscopists have devoted much time and attention to its investigation. Notwithstanding our ignorance of its chemical

933. Med.-Chir. Trans. vol. viii. pp. 117, 121, 139.

934. Prout, Bridgewater Treatise, p. 356.

and physical properties, there is every reason to believe it to be an organic compound, composed chiefly of hydrogen and carbon, abundantly disengaged from the earth's surface by the solar rays, and diffused, during the day, through the atmosphere, and to be precipitated, after sunset, in a condensed form in proportion to the diminution of temperature.

935. *Marsh miasma* consists of gaseous matters, the product of purely chemical, or physical, or physiologically chemical actions, taking place within the earth, or upon its surface, in stagnant waters, or in the atmosphere itself. (*Schönbein.*) In other words, marsh miasm consists of invisible and pestiferous emanations from the surface of the earth, and of poisonous gaseous exhalations and effluvia from animal and vegetable matter in a state of decomposition.

936. A certain degree of *moisture*, and a somewhat *elevated temperature*, are as indispensably necessary to the development of malaria as to the oxidising processes of decay and putrefaction. All these processes are alike suspended by *perfect dryness*, and by a temperature *below the freezing point.*

937. Dr. R. D. Thomson, Professor of Chemistry at St. Thomas's Hospital, examined the atmosphere of the cholera wards of that Institution, and found animal and vegetable life unequivocally diffused throughout it; fungi, or their sporules, and germs of vibriones, or vibriones themselves.

938. In the external air, adjacent to the Hospital, during the epidemic cholera period, he found sporules with fungi to a considerable extent, but no vibriones.

939. The atmosphere of a *sewer* was found to contain sporules, fungi, and vibriones.

940. The external atmosphere and that of the wards possessed an acid reaction; that of the sewer gave an alkaline reaction.

941. Mr. Rainey, Demonstrator of Microscopical Anatomy at St. Thomas's Hospital, also examined the atmosphere of the cholera wards, and found in it "living organic bodies," which

were ascertained to consist of the myeelia of fungi apparently in an active state of vegetation, associated with more or less extraneous vegetable fibres. Besides the fungi, there was abundance of extremely minute, colourless, indistinctly beaded fibres, resembling in their general characters that form of vibrionia called "bacterium."

942. Whether fungi or their spores, or vibriones or their germs, exist in marsh miasmata, has not yet been determined.

943. We are told, on the authority of M. Boussingault, that the inhabitants of South America successfully withstand attacks of endemic diseases by covering the nostrils and mouth with a veil, so as to sift the air from all morbid particles.

944. *Marsh miasma* is peculiarly and naturally associated with marshes and swamps. "The essential character of these," says Dr. Macculloch, "is, that the land should be partially inundated, that it should be dry in some places and wet in others, or that pools and dry spots should be intermixed, or that it should be boggy and soft from the mixtures of earth and decayed vegetables with water, or that it should be subject to peculiar alternations of moisture and dryness, sometimes amounting to absolute inundation in the first case."

945. Malaria abounds in swampy and marshy districts, but more especially in salt water marshes; on the drying or half dried borders of lagoons and lakes; on sandy plains which have been flooded and have subsequently become dry; on alluvial shores; on the deltas, and in the course of tidal rivers, whose mud banks, rich in decayed and putrefying animal and vegetable matters, are twice in every twenty-four hours alternately covered and uncovered by the ocean tide, and as often exposed to the decomposing influence of the oxygen of the atmosphere —may be, to the heat of the solar rays.

944. Malaria: an Essay on the Production and Propagation of this Poison, and on the Nature and Localities of the Places by which it is produced, &c. by John Macculloch, M.D., F.R.S. London, 1827, vol. i. p. 61.

946. Loose, porous, sandy, alluvial, and argillaceous soils; deep, loamy, marly lands with a substratum of clay, affording capacity for the retention of moisture; plains and level countries presenting physical obstacles to underground drainage, are most favourable during a high range of temperature to the development and extrication, in all their virulence and intensity, of malarious exhalations, the *product of underground moisture*, of which the *surface gives no warning.*

947. Dr. William Fergusson has endeavoured to prove that *malaria*, and the products of *animal* and *vegetable* matter in a state of decomposition, are *three distinct things*, and, though often in company, have no necessary connection with each other; and that neither of the two last is essential to the production of pestiferous miasmata, or sufficient to generate fever; and, further, that the pestiferous quality of marsh miasmata does not necessarily depend upon *aqueous* putrefaction; that malaria never, under any circumstances, proceeds from open masses of water, but that, on the contrary, the mephitic emanations of marsh lands approaching to dryness from previous drought are corrected and destroyed by abundant rains, and thé pestiferous lands themselves rendered perfectly healthy by accumulations of water on their surface.

948. The immortal Shakspeare makes frequent allusion to the source, development, and noxious effects of marsh miasm: thus—

949. CALIBAN. As wicked *dew* as e'er my mother brush'd
With raven's feather from *unwholesome fen*,
Drop on you both.

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946. Watson, op. cit. p. 739.

947. An Inquiry into the Origin and Nature of Yellow Fever, by William Fergusson, M.D., Inspector of Hospitals, and principal Medical Officer in the Leeward and Windward Islands. Medico-Chirurgical Transactions, vol. viii. p. 129.

949. Tempest, Act I. Scene 2.

950. CALIBAN. All the *infections* that the *sun sucks up*
From *bogs, fens, flats*, on Prosper fall, and make him
By inch-meal a *disease.*

951. CORIOLANUS. Though I go alone,
Like to a lonely dragon, that his *fen*
Makes fear'd and talk'd of more than seen.

952. Malaria is *decomposed* and *rendered inert* by *fire and smoke.*

953. Lancisi mentions this fact in connection with Rome. Pliny, who expresses the same opinion, and quotes the authority of Empedocles and Hippocrates to the same effect, states that the Athenians were cured of the plague by *lighting fires* near the houses of the sick. In more modern times the postmaster at a station in the Pontine Marshes preserved his health and flesh by keeping a fire constantly burning in his house day and night throughout the year. The cholera was arrested at Varna by the conflagration of the town.

954. It is probable that malaria is decomposed or destroyed by the carbonaceous or mineral atmosphere of crowded and of manufacturing cities. Manchester and Birmingham passed through the cholera periods almost unscathed. This immunity from disease was attributed to the mineral matters from the numerous furnaces of these towns, with which the atmosphere was loaded.

955. *Metallic gases* are *not* malarious, unless combined with animal and vegetable matter in a state of decomposition.

956. The *specific gravity* of malaria is considerably greater than that of the atmosphere.

957. On the 9th February, 1832, Dr. Prout, who had been for some weeks engaged in "endeavouring to determine, with the utmost possible accuracy, the weight of a given quantity of air," found it "suddenly rise above the usual standard,"

950. Tempest, Act II. Scene 2.
951. Coriolanus, Act IV. Scene I.
954. Macculloch, op. cit.
957. Bridgewater Treatise, pp. 353, 354, 355.

which he explained "by admitting the diffusion of some gaseous body through the lower regions of the atmosphere considerably heavier than the air it displaced." "About this day, the 9th of February, the first cases of epidemic cholera were reported in London." Dr. Prout "believes that the virulent disease, termed cholera, was owing to the same matter which produced the additional weight of the air;" and that "the foreign body diffused through the atmosphere of London, in February 1832, was probably a variety of *malaria.*"

958. On this day, at 3 P.M., the reading of the barometer, recorded at the Royal Society's House, was 30·395 inches. The mean weight of a cubic foot of air is stated by Mr. Glaisher to have been two grains above the annual average.

959. Malaria, in consequence of its great *specific gravity*, is found in its utmost intensity in valleys, intermingled with mists and fogs; on the earth's surface, combined with the aqueous vapour of the atmosphere; entangled and stagnant in the coarse vegetation of the jungle of the East; in the dank grass, strong weeds, and dense brushwood of the West Indies; at the bottom of moats and ditches surrounding fortified towns; on the ground-floors of our dwellings; and in underground apartments.

960. "In all malarious districts and seasons the inhabitants of *ground-floors* are uniformly affected in a greater proportion than those of the *upper* stories. According to official returns, the proportion of those attacked in the lower apartments of the barracks at Barbadoes exceeded that of the upper by *one-third.*"

961. It was observed and recorded by the Registrar-General, during the two last invasions of pestilential cholera in this country, "That, whilst the *leaven* of the disease seemed to have been universal throughout the metropolis, the conse-

958. Meteor. of London, p. 100.

960. Assistant Surgeon Ralph, 2nd or Queen's Regiment, Appendix x. Med.-Chir. Trans. vol. viii. p. 170.

quences varied in different localities; and that, independently of any hypothesis, such local varieties were found to be more nearly *inverse to the elevation of the soil* in the affected districts than proportionate to any other general influence."

962. Thus, out of every 10,000 on or below the level of high-water mark, the mortality was 156; in the districts of 3 and under 20 feet of elevation, 91; of 20 to 40 feet, 44; of 40 to 60 feet, 36; of 60 to 80 feet, 23; of 80 to 100 feet, 17; and at 350 feet of elevation, only 10.

963. Illustrative of the difficulty with which malaria attains to elevated situations, and ascends the mountain-top; significant also of the greater immunity from the effects of marsh miasmata enjoyed by these, compared with less elevated localities, Dr. Ferguson states that "the British garrison of English Harbour, in the island of Antigua," "were distributed, in 1816, on a range of fortified hills which surround the dock-yard. The principal of these, Monks' Hill, rises perpendicularly above the marshes to the height of 600 feet; another garrisoned hill, the Ridge, is about 100 feet lower; and a third, about 300 feet above the swamps, was occupied by seventeen artillery soldiers. The white troops in the two upper forts took the guards and duties of the dock-yard amongst the marshes below; and, so pestiferous was their atmosphere, that it often occurred to a well-seasoned soldier, mounting night-guard in perfect health, to be seized with furious delirium while standing sentry, and, when carried back to his barrack, to expire in all the horrors of the black vomit within less than thirty hours from the first attack." "Those of the troops in the Monks' Hill Barrack who were not obliged to *sleep* out of the garrison, or take the duties below, *remained in perfect health*." "In the Ridge Barrack *scarcely any fever* worthy of notice occurred." "The artillery

963. On the Nature and History of Marsh Poison, by William Ferguson, M.D., F.R.S.E., Inspector of Army Hospitals. Transactions of Royal Society of Edinburgh, vol. ix. pp. 285, 286.

soldiers, who occupied the barrack 300 feet above the marshes, were *all* attacked with *remittent fever*, of whom one died."

964. "The solution here seems easy," says Dr. Macculloch; "it is, that the malaria is especially united with that transferable substance which forms the foggy stratum, or that the lowest portion of the atmosphere, in the act of depositing water, is its vehicle and its residence."

965. In Holland, America, and in this country, it is generally believed that malaria is conducted by common fogs, and that the pernicious nature of these is caused by the intermixture of malaria.

966. Again, malaria is met with on *hills* and *elevated spots*. Its *effects* are, however, *modified by altitude.* If the elevation be considerable, the *temperature will necessarily restrict the fever* arising from malaria *to the intermittent form;* whilst, in the plain beneath, the same noxious emanations would produce, in tropical climates, *remittent* or *yellow fever, plague,* or *pestilential cholera.* (928.)

967. In Sicily, according to Captain Smyth, out of seventy-six unhealthy towns and villages, thirty-five are situated on hills and declivities. It is supposed that the *warm* southern winds not only produce, but readily waft upwards among the hills, the malaria of the emanating districts.

968. Assuming these localities to be free from all local malarious exhalations, is it not possible, indeed probable, that the miasmata of the lower districts are rendered specifically lighter, and are borne upwards to these thirty-five towns and villages on "*clear* and *still nights*," by the radiation into successive strata of malarious atmosphere of a portion of that heat which the earth had acquired from the sun's rays during the day?

969. It will be recollected that M. Pictet, Mr. Six, and

964, 965. Op. cit.
967. Ibid. ch. vii. p. 244.

Dr. Wells have ascertained that in *every clear and calm night* the temperature of the atmosphere *increases* with the distance from the earth to the height of at least 220 feet, and that at this elevation the atmosphere is frequently 10 degrees warmer than the stratum only 7 feet from the ground (91).

970. Marsh miasm is *borne by the winds* from place to place; indeed, it may be said to ride on the back of the atmosphere. Its progress is, however, retarded by lofty buildings, and its course altogether diverted by mountain chains.

971. Lancisi tells us that, of thirty ladies and gentlemen who had sailed to the mouth of the Tiber, twenty-nine were immediately attacked with tertian ague, on the wind shifting and blowing over a marsh to windward of them.

972. During certain states of *stagnation of atmosphere* miasmata accumulate in and about towns and villages, but more especially in and among coarse damp vegetation and underwood.

973. It has been remarked in the Campagna of Rome, that, if the labourers cut down certain bushy thistles, fever is the consequence. The malaria is supposed to be entangled within the vegetation, and to be let loose by this disturbance.

974. Dr. Fergusson is of opinion that the healthiness of seasons in unhealthy climates depends less on the amount of actual heat and moisture than on the *ventilation* of such localities by powerful and regular winds; and that towns and districts of country will be found, *cæteris paribus,* to be healthy or otherwise in proportion as they enjoy more or less of this purifying influence.

975. Dr. Chambers, principal medical officer of the Island of St. Lucia, entertaining similar opinions respecting *ventilation*, *draining,* and *clearing*, suggested the desirableness of

971. De Noxiis Paludum Effluviis, Roma, 1717.

973. Macculloch, op. cit. p. 267.

974. Med.-Chir. Trans. vol. viii. p. 141.

975. Addenda to the Queen's Regulations and Orders for the Army, p. 86.

removing all superabundant vegetation, brushwood, strong weeds, rank grass, &c. from the immediate vicinity of the military stations of the island. The salutary effects resulting from this procedure having been brought before the late Commander-in-chief, his Grace the Duke of Wellington, and confirmed by the Director-General of the Medical Department of the Army, Sir James M'Grigor, his Grace directed a "*Circular*" to be forwarded to all "*General* (*or other*) *Officers commanding at Foreign Stations*," "enjoining the adoption of similar precautions in all the other military stations of our West India possessions."

976. In the years 1845, 1846, *previously* to the draining, clearing, and cutting through the dense mass of vegetation in the vicinity of the military station in the Island of St. Lucia, the proportion of deaths from fever among Europeans was no less than nine out of eleven cases; whilst in 1847, *subsequently* to the cutting down and removal of the brushwood, the average was only one in eight cases.

977. The noxious effects of malaria are, for the most part, produced in all their virulence and intensity in *autumn*, after the heat and drought of summer. The *hotter and drier* the preceding summer, the more frequent and more fatal are the autumnal fevers. The *colder and moister* the season the less frequent and less severe are the attacks.

978. The emanations of malarious districts are most pestiferous and most active from *sunset to sunrise*; and, on account of their great specific gravity, are most virulent and intense *close to the surface of the earth*. Hence the imminent peril of *lying down to sleep at night* in the open air in pestilential localities. Indeed, Lancisi strongly urges travellers not even to *cross* the Pontine marshes *by night*.

976. Addenda to the Queen's Regulations and Orders for the Army, p. 88.

977. Celsus, Livy, Strabo, Horace, Martial.

978. Op. cit.

979. Nay, further, it has been remarked in many parts of Italy that the day-labourers are only safe so long as they observe the erect posture, and that if they sit or lie down on the ground they are in great danger, as though the poisonous matter extended to but a small altitude above it. (930.)

980. The generation of malaria is lessened or prevented by the *culture of the soil.*

981. Nothing checks the generation and propagation of malaria so much as dense population and *high cultivation.*

982. A certain amount of drainage may, however, just bring a swamp, which is too wet to produce miasmata, into that state which is peculiarly favourable to their extrication. The drainage of the marsh of *Chartreuse,* near Bordeaux, was followed, for many years, by a succession of severe forms of fever before unknown. In 1805, 12,000 persons were attacked, of whom 3,000 died within five months.

983. On the other hand, in districts naturally producing malaria, which have been suffered to fall out of cultivation, intermittent and remittent fevers multiply.

984. The noxious qualities of marsh miasm are destroyed or absorbed in its passage across a river, or over the surface of even a small body of water. This is probably due to the presence of ozone resting on the surface of the water.

985. It would appear that when the mean daily temperature of the waters of a river in temperate latitudes, those of the Thames, for instance, exceeds 60° Fah., and is, *at the same time, in excess of the minimum* temperature of the air, the waters will exhale into the atmosphere mephitic gases, the product of the putrefactive decay of such animal and vegetable matters as may be held in solution by them. (1060.) Whether

979. Macculloch, op. cit. vol. i. p. 268.

982. Ibid. p. 115.

983. Watson, op. cit. vol. i. p. 752.

984. Sir Gilbert Blane, Med.-Chir. Trans. vol. iii. p. 27.
William Ferguson, M.D. Trans. Roy. Soc. Edinburgh, vol. ix. p. 293.

this will be found to obtain in warmer latitudes remains to be proved.

986. Its poisonous properties are *arrested*, and probably *neutralised, decomposed, absorbed,* or *respired,* by plants, by large thick leafy trees, by dense groves and forests, by masses of foliage, and by evergreen shrubs.

987. Pliny was of opinion that "groves and trees *absorb* and *destroy* mephitic vapours." Dr. Macculloch, no mean authority, whilst admitting the "real truth of Pliny's remark that trees destroy or consume mephitic vapours," denounces his 'theory to be unfounded, and his philosophy inaccurate.' A country, says he, may become unhealthy by cutting down trees, and thereby exposing to the developing influence of the solar rays the wet and previously shaded ground; and, reversely, the planting of trees will sometimes check the production of malaria, by protecting wet lands from the action of the sun, and by absorbing and dissipating moisture.

988. This reasoning is not conclusive. It may be suggested that in the former case terrestrial emanations were given off equally *before* as after the trees were cut down, but were *absorbed* by them; and that, in the latter case, terrestrial emanation was not 'checked but absorbed' by the trees as rapidly as evolved.

989. The result, however, of our experiences tends very considerably to confirm Pliny's view of the subject.

990. We have seen (650, 651,) that plants, *during the day*, but more especially during *sunshine*, absorb from the atmosphere, and decompose, *carbonic acid,* and *restore* its *oxygen* to the air. We have also seen (652) that during the *night* the leaves of plants *absorb oxygen,* and *give off carbonic acid.* At least, if they do not *give off* carbonic acid, they do not *absorb* it. Is it assuming too much, then, to suppose that an all-wise Providence, in his mercy, has ordained that the mephitic

987. Op. cit. vol. i. p. 167.

emanations from the earth's surface, and the poisonous products of eremacausis, be *neutralised* and *respired* by the leaves of plants. Have we not seen (978) that malaria is most pestiferous and most active *from sunset to sunrise,* when plants *respire oxygen* and *give off carbonic acid*, when, in fact, they *cease to absorb* carbonic acid, and, *probably*, *marsh miasm.*

991. The noxious effects of malaria are, for the most part, produced in *autumn*, when the last "sere and yellow leaf" has fallen to the ground, and all vegetation is preparing for its sabbatical rest, and leaving marsh miasm to do its deadly work unchecked and uncontrolled.

992. If, however, during the *winter* months, we are deprived of the antidotal influence of vegetation in neutralising, or absorbing and decomposing, the noxious effects of malaria, we are mercifully supplied with another equally effectual and protective agent in the *low temperature* of this season of the year.

993. In warm latitudes and intertropical climates, where malaria abounds in all its intensity, many of the trees retain their foliage throughout the entire year, such as the lemon, the lime, the orange, the almond, the tamarind, the *Cupressus disticha,* the *Juniperus Virginiana*, the *Pinus tæda*, *Pinus palustris,* &c.

994. Returning *spring* brings vegetation to interpose its benign and kindly offices between us and marsh miasm; and, as though this were not sufficient to meet the exigencies of the summer season, we have mercifully superadded, for our requirements, an *elevated temperature,* as destructive of malaria as the cold of winter.

995. The violence of the plague itself is restrained within certain limits of atmospheric temperature, and does not spread when Fahrenheit's thermometer rises above 90°, or sinks much below 60°.

996. It is an admitted truth that *peat bogs* do not generate, or at least do not emit, malaria. The question naturally arises, whether the peculiar *vegetation* with which the surface

995. Copland's Dictionary of Practical Medicine, article "Pestilential Cholera."

of these bogs teems during the summer months does not absorb or respire any malaria which may be exhaled from the surface of the earth, and whether, in winter, when the decay or death of this vegetation takes place, the *temperature* of these localities is not unfavourable to the extrication of malaria.

997. It only remains to be shown that malaria abounds in its most concentrated and deadly form where *little or no vegetation exists to deprive it of its poisonous properties;* and that *where vegetation does exist in abundance, with free ventilation, malaria is rendered almost, if not entirely, innocuous.*

998. Dr. Ferguson writes: "Another property of the marsh poison is its attraction for, or rather its adherence to, lofty umbrageous trees." "In the territory of Guiana particularly, *where these trees abound,* it is wonderful to see how near to *leeward* of the most pestiferous marshes the settlers, provided they have this security, will venture, and that *with impunity,* to place their habitations." "At Paramaribco, the capital of Surinam, the trade-wind, which regularly ventilates the town and renders it habitable, *blows over a considerable tract of swamp* at a short distance, but which, fortunately for the inhabitants, is *thickly covered with umbrageous forests.* Experience, besides, has shewn, that there, as in all other new lands, the *cutting down of those trees in the swamps has ever been a fatal operation* in itself, and in all probability would be *productive of pestilence* to the town."

999. Numberless outbreaks of fever, of various types, during the peninsular war, are also recorded by Dr. Ferguson, and it will be seen that in almost every instance the locality in which the disorder appeared was *devoid of all vegetation.* The annihilation, by fever, of the British army at Walcheren is probably attributable to a like cause, the emanation of malaria from a sandy soil *devoid of trees and vegetation.*

1000. "Intermittent and remittent fevers became endemic in our army in August, 1794, when, after a very hot and dry

998. Trans. Roy. Soc. Edinburgh, vol. ix. p. 286.
1000. Ferguson, op. cit. p. 276.

summer, our troops took up the encampments of Rosendaal and Oosterhout, in South Holland. The soil in both places was a level *plain of sand*, with perfectly dry surface, where *no vegetation existed*, or *could exist*, but stunted heath plants."

1001. The same absence of vegetation at Walcheren is recorded by Sir Gilbert Blane. "The whole island, with the exception of some hills, or rather mounds, of sand on the western shore, is a *dead flat* below the level of the sea at high water and preserved from inundation by dykes. The soil consists of a fine *white sand*, known in the eastern counties of England by the name of silt, and about a third part clay."

1002. The poisonous exhalations of the alluvial sandy plains of Zealand all but exterminated, in less than five months, a British army 43,521 strong, exclusive of reinforcements subsequently sent out. The expedition landed on Walcheren, and North and South Beveland, on the 31st July and 1st August, 1809. Sir Gilbert Blane reports on the 30th September, that no less than "two-thirds of the whole numerical strength of the army were incapable of duty, and that the mortality averaged 250 per week." "The total number of admissions into the hospitals in Zealand, between the 21st August and 18th November, 1809, amounted to the incredible number of 26,846, including relapses, and that the number of sick, including a few wounded men, conveyed to England, between the 21st August and the 16th December, amounted to 12,863." "Of 18,000 men left to garrison Walcheren, more than one-half died, or were sent to England on account of sickness during the three following months."

1003. The frightful amount of mortality experienced by this expedition is scarcely paralleled by the loss of the French army in their attempt on Naples in 1528, when, by choosing unhealthy encamping ground at Baia, an army of 28,000 was, *in a few days*, reduced to 4,000 men!

1001. Med. Chir. Trans. vol. iii. p. 16.

1002. Sir Gilbert Blane, Med. Chir. Trans. vol. iii. pp. 10, 11.

1004. "In June, 1809, the army advanced towards Spain, through a singularly dry rocky country, of considerable elevation, on the confines of Portugal. The weather had been so hot for several weeks as to dry up the mountain streams; and in some of the hilly ravines that had lately been water-courses, several of the regiments took up their bivouac. Several of the men were seized with violent remittent fever before they could move from the bivouac the following morning. Till then it had always been believed that vegetable putrefaction (the humid decay of vegetables) was essential to the production of pestiferous miasmata; but in the instance of the half-dried ravine before us, from the stony bed of which (as soil never could lie for the torrents) the *very existence even of vegetation was impossible*, it proved as pestiferous as the bed of a fen."

1005. "After the battle of Talavera the army retreated into the plains of Estramadura, along the course of the Guadiana River, at a time when the country was so *arid* and dry, for want of rain, that the Guadiana itself, and all the smaller streams had, in fact, *ceased to be streams,* and were no more than lines of detached pools in the courses that had formerly been rivers, and there they suffered from remittent fevers of such destructive malignity, that the enemy, and all Europe, believed the British host was extirpated." "The aggravated cases differed little or nothing from the worst yellow fevers of the West Indies; and in all the subsequent campaigns of the Peninsula the same results uniformly followed, whenever, during the hot seasons, any portion of the army was obliged to occupy the *arid* encampments of the level country, which at all other times were healthy."

1006. "Salvaterra, a large village and royal hunting residence, about a mile from the banks of the Tagus on the Alentejo side of the river, is always reputed to be very healthy until the beginning of the autumnal season, when every person

1004, 1005. Ferguson, op. cit. pp. 276, 277.
1006. Ibid. p. 278.

who has the means of making his escape flies the place. The country around is *perfectly open*, though very low, and flooded with water during the whole of the rainy season; but at the time of the periodical sickness it is always most distressingly *dry*. I have visited it on these occasions, and found it the *most parched spot* I ever saw. The houses were literally buried in dry loose sand, that obstructed the doors and windows."

1007. "Ciudad Rodrigo affords another instance of the same. It is situated on a rocky bank of the river Agueda, a remarkably clear stream; but the approach to it on the side of Portugal is through a *bare* open hollow country, that has been likened to the dried-up bed of an extensive lake; and upon more than one occasion, when this low land, after having been flooded in the rainy season, had become as dry as a brick-ground, with the *vegetation utterly burned up*, there arose to our troops fevers, which for malignity of type could not be matched by those before mentioned on the Guadiana."

1008. "At the town of Corea, in Spanish Estramadura, not very dissimilarly situated, on the banks of the Alagon, our troops experienced similar results. The shores of the river (it had no confining banks) seemed perfectly dry, and there was *not* an *aquatic weed*, nor a speck, nor line of marsh to be seen within *miles* of the town, nor anything but dry, *bare*, and clean savannah."

1009. "From all the foregoing it will be seen that in the most unhealthy parts of Spain we may in vain, towards the close of the summer, look for lakes, marshes, ditches, pools, or *even vegetation*. Spain, generally speaking, is then, though as prolific of endemic fever as Walcheren, beyond all doubt one of the driest countries of Europe; and it is not till it has again been made one of the wettest, by the periodical rains, with its *vegetation* and *aquatic weeds restored*, that it can be called healthy, or even habitable, with any degree of safety."

1007, 1008, 1009. Ferguson, op. cit. pp. 278, 279, 280.

1010. Sullivan, in his "Visit to Ceylon," advances similar opinions on the subject of the absorption by plants of noxious exhalations. "The vicinity of tanks and lagoons of the most fœtid and agueish character is perfectly healthy. These are covered in abundance with various kinds of aquatic plants, the lotus, of almost Victoria Regia magnificence, which, by a kind Providence, are made to serve not only as filterers and purifiers of the water itself, but even as consumers of a considerable portion of the noxious exhalations that would otherwise poison the neighbourhood."

1011. "A forest," says Mr. Haviland, "intervening between a pestilential marsh and a city often affords a protection to the inhabitants, and perchance the pestiferous air gets decomposed into innocuous gases during its enlargement among the trees."

1012. At Lisbon, and throughout Portugal, are *numerous* and *extensive gardens*, for the supply of which, during the three months' absolute drought of the summer season, water is preserved in very large stone reservoirs. The water falls into the *most concentrated state of foulness and putridity*, diminishing and evaporating day after day, till it subsides either into a thick green vegetable scum, or a dried crust. These reservoirs may be seen in this state close to the houses, even to the sleeping-places of the household, in the atmosphere of which they literally live and breathe; "yet no one ever heard or dreamt of fever being generated amongst them from such a source, though the most ignorant native is well aware that, were he only to cross the river, and sleep on the *sandy shores* of the Alentejo, where a *particle* of water at that season had not been seen for *months*, and where water, being absorbed into the sand as soon as it fell, was *never* known to be *putrid*, he would run the greatest risk of being seized with remittent fever."

1013. In fact, the southern bank of the river is a sandy and

1011. Climate, Weather, and Disease, by Alfred Haviland. London, 1855. p. 78. Ferguson, op. cit. pp. 288, 289.

highly pestiferous plain. The northern bank, on the contrary, is perfectly healthy. The country on this side is hilly, and the foundation of the soil, and of the beds of the streams, is of basaltic rock, covered here and there with limestone. The quintas, or gardens, are of *considerable extent,* and for the most part contain *plantations* of *orange and olive trees.* These latter abound in all open spots. The *cypress and judas trees*, *elms and poplars*, are also met with in abundance in the surrounding country.

1014. "It is a remarkable fact," says Dr. Watson, "that, though the provinces of North America, especially North and South Carolina and Virginia, are full of ague, that disease is never seen among the inhabitants of the *Dismal Swamp*—a moist tract of 150,000 acres on the frontiers of Virginia and North Carolina."

1015. The "*Dismal Swamp*" extends from north to south nearly 30 miles, and averages from east to west nearly 10 miles. It is covered, in common with all the other swamps of that country, with *evergreen trees* of *huge* and *lofty stature.* The deciduous cypress, *taxodium distichum,* attains a height of 120 feet; the red cedar, *Juniperus Virginiana,* reaches to 80 feet; the pines, *pinus tæda* and *pinus palustris,* from 60 to 80 feet. All these *retain their foliage throughout the entire year.*

1016. The convent of St. Stephano became *unhealthy in consequence of cutting down some trees;* and the *extirpation of a wood* brought on *severe fevers* at Velletri, during a space of *three years.* The *same results* occurred, *from like causes,* at Campo Salino, in the Pontine Marshes.

1017. The site of ancient Rome, as well as the surrounding country, was a tract of *woods,* lakes, and marshes. The plain of Latium, according to Theophrastus, was *covered,* especially towards the sea, by *forests of laurel* and *myrtle* of such a size

1014. Op. cit. vol. i. p. 739.
1016, 1017. Macculloch, op. cit. vol. i.

as to be used in ship-building, "constituting, doubtless, screens to protect the country from the pernicious southern winds, and to check the propagation, if not the production, of malaria." Rome flourished, Latium was rich and *populous*, and the lake of Castiglione was the seat of a *powerful city*.

1018. In later times, says Lancisi, a *forest* to the southward of Rome, reaching from the heights of Frascati and Albano to the Tiber, which protected it from malaria, so abundantly generated in that quarter by marshes, was *extirpated*, and *destruction* first let in upon the Campagna. A *similar* proceeding, in another quarter, exposed the Eternal City itself to the *malaria* of these localities.

1019. In 1695, after a great overflowing of the Tiber, the inhabitants of Rome were attacked with agues and remittent fevers, with the exception of those who resided in one particular quarter of the city, "which *was protected by a belt of trees around it*."

1020. Although lakes and marshes have now comparatively disappeared under various attempts at drainage, Castiglione is infamous for its pestilential air, the plain of Latium and the country surrounding Rome are *uninhabited deserts*, and the Eternal City herself is frequently sorely visited by fevers of a remittent form, which, we are told by Dr. Armstrong, are "*attributed to the felling of forests*," which protected her from the pestilential emanations of the surrounding miasmatic districts.

1021. Whether Dr. Ferguson has or has not succeeded in establishing his views, (947,) we need not stop to inquire: he, as well as Sir Gilbert Blane, (1001,) has at least, though unweetingly, demonstrated that the *absence of vegetation may be received*

1018, 1019. Op. cit.

1020. Macculloch, op. cit. vol. i. p. 165.

Lectures on the Morbid Anatomy, Nature, and Treatment of Acute and Chronic Diseases, by John Armstrong, M.D., edited by Joseph Rix. London, 1834. p. 550.

as a tolerably sure indication of the presence of malaria. Whilst, on the other hand, it has been as clearly shown (998, 1009, 1010, 1014, 1017, 1018, 1019) that the *absence of malaria may be fairly inferred from the presence of vegetation.*

1022. Whether, then, vegetation act by *absorbing* and *decomposing* marsh miasma, or by *exhaling oxygen* into the atmosphere, is of little moment. In the former case, the miasma is destroyed by the vegetation, *directly;* in the latter, *indirectly,* by the conversion, through the agency of electric influences, electrical discharges, and thunder-storms, of the excess of oxygen exhaled into the atmosphere, into *Nature's grand and universal disinfectant,* OZONE.

1023. In either case it is worthy of consideration whether swamps, moors, fens, and marshes may not be rendered comparatively salubrious, or at least innocuous, by planting them with a fair amount of evergreen trees and shrubs.

1024. Practically, then, we are taught, in the choice of encamping grounds for troops, to avoid marshes, fens, and moors, valleys, and low-lying lands, limestone rock, and arid and sandy soils, the banks of tidal rivers, and the course of dried-up water-streams, but, more especially, should we shun malarious localities if destitute of vegetation, or if this exist in a scanty degree only.

1025. If necessity, however, compel an encampment near to marsh or paludal lands, care should be taken that the tents be pitched on the windward side of the emanating districts; and, where possible, that trees intervene between these and the troops. If the former be impracticable, and the latter do not exist, large fires should be kept constantly burning between the camp and the malarious lands.

1026. On the other hand, we are taught to select high-lying lands, gravelly or chalky soils, well-wooded districts, a southern aspect, sheltered from the north and east winds by mountains or hills, but more especially by umbrageous trees or dense and lofty forests.

Drains, Sewers, Ditches, Cesspools.

1027. Inseparably associated with marsh miasma, and all but identical in their effects upon the human body, are the pestiferous and morbific exhalations elaborated from imperfect drains, open sewers, and cesspools of towns and cities.

1028. In all large cities and towns there are plague-spots where fever of the intermittent, remittent, or continued form always prevails in greater or less intensity. There are districts and localities in our modern Babylon which are ever emitting the poison which generates typhus fever; there are certain squares and streets, nay, particular houses, the inmates of which, family after family, for a long series of years, have been the victims of typhus fever, though the districts in which they are situate are airy, and the soils dry.

1029. Open and imperfect common sewers, faulty, superficial, choked up, and overflowing drains, imperfect traps of cesspools and water-closets, a filthy condition of the earth's surface, together with intramural burial-grounds, slaughter-houses, and slaughtering-cellars, and the conversion of tidal rivers into cloacæ maximæ, are the fruitful sources of fevers, diarrhœa, and dysentery in all congregations in any one spot of huge multitudes of human beings.

1030. There is probably no subject so complex, so incalculably difficult to grapple with, especially if it be how to apply a remedy, as the drainage and sewerage of large overgrown cities. Yet, we must perceive, that unless this be efficiently done, an ultimate limit is set by the hand of man himself to dynasties, to peoples, and to nations. The air we breathe, loaded with carbonaceous matter, sulphurous, and sulphuric acid, sulphate of ammonia, and sulphuretted hydrogen (18), is deprived, by the absence of vegetation, of the revivifying principle oxygen, and is hence less fitted for the necessary changes of the blood effected during respiration. The earth which we tread under our feet, loaded with the ashes of our forefathers,

and rich with the remains of animal and vegetable matter of ages long gone by, saturated with the putrefying contents of myriads of cesspools and leaking sewers of our own day, emits, at certain seasons of the year, the poisonous emanations which generate typhus, diarrhœa, dysentery, and cholera; whilst the waters of our principal tidal rivers, converted into open common sewers, teem with pestiferous exhalations charged with the germ of disease or the messenger of death. If, under these favouring conditions, a pestilential epidemy invade our shores, it finds us an unprepared and easy prey.

1031. The Government of every state and nation would do wisely to appoint a Minister of Public Health, whose duty it should be to superintend and watch over the health of the community at large, to see that due ventilation is observed in all large and public buildings, and in the dwellings of the poor; to ascertain that the water is pure, and its supply ample; to prevent all noxious and unwholesome trades and manufactures being carried on within a given distance from towns and dwellings; to prohibit intramural burial-grounds, slaughter-houses, and slaughtering-cellars; but, above all, to lay down, and carry out, an effectual, efficient, complete, and common-sense plan of drainage and sewerage for every town and city.

1032. The beneficial results likely to accrue to the communities of large towns in particular, and to the whole country at large, by the appointment of a Ministry of Health, may be estimated, comparing small things with large, by contrasting the diminution in the mortality of the "*City*" of London, under the able and judicious supervision of Dr. Letheby, the "medical officer of health" appointed by the Commissioners of Sewers of the City of London, with that of previous years.

1033. Dr. Letheby, in his "Report for the quarter ending June 30th, 1857," states "the mortality to have been 684, whilst the average of the last eight years, for the same quarter, was 755. The average rate of mortality for this quarter was thus reduced to 21 in 1,000, whilst the average death-rate of

all London for the corresponding period was 25 in the 1,000; of our large towns, 24·7; and of all England, 22·7;" conclusive evidence that "the sanatory measures are not applied without good effect, and that the same principles of action are not unworthy of imitation."

1034. Were the fearful consequences which result from the reprehensible practice of converting our rivers into open common sewers but thoroughly understood, and properly estimated, by the public, no expenditure of time or money would be deemed too great to put an end, by penal enactment, to a system so disgusting, so revolting, and so destructive to the health and lives of the community at large; but more especially of those whose avocations necessitate their daily and hourly exposure to, and residence in the midst of, its pernicious influence.

1035. Unless this monstrous and suicidal evil be stayed, London will ultimately become the hot-bed of plague and pestilence, and will, as a consequence, be depopulated and deserted, and numbered with the cities of the world which have been. Then, perhaps, may be fulfilled the prophetic visions of Volney, of Walpole, of Shelley, of Macaulay, "when London shall be an habitation of bitterns; when St. Paul's and Westminster Abbey shall stand shapeless and nameless ruins, *in the midst of an unpeopled marsh;* when the piers of Westminster Bridge shall become the nuclei of islets of reeds and osiers, and cast the jagged shadows of their broken arches on the solitary stream;" or, with Macaulay, "when travellers from distant regions shall in vain labour to decipher on some mouldering pedestal the name of our proudest chief; shall hear savage hymns chanted to some misshapen

1035. Les Ruines, par C. F. Volney, chap. ii. p. 10.
Horace Walpole to Sir H. Mann.
Peter Bell the Third, by P. B. Shelley.
On Mitford's History of Greece, Knight's Quarterly Magazine, Nov. 1824, p. 303.

idol over the ruined dome of our proudest temple; and shall see a single naked fishermen wash his nets in the river of the ten thousand masts."

1036. "Of the drainage area of London," writes Dr. Sayer, "upwards of 108 square miles, or 69,120 acres, are covered with buildings. The length of the public sewers in the City itself is upwards of 50 miles; and of the metropolitan public sewers, including brick and pipe sewers and open ditches, upwards of 1,334 miles:" all of which discharge their pestilential contents in the very heart of our great metropolis, into the river Thames, which thus becomes "the common recipient of filth from a population exceeding 2,500,000 souls, from thousands of domestic animals, and from an average of 1,787,459 cattle annually slaughtered within its boundaries." Its waters are thus "polluted *per minute* by a sewage flow on its north bank of 13,489 cubic feet, or 84,077 gallons; and on its south bank by 4,565 cubic feet, or 28,454 gallons." "The *daily* quantity of feculent sewage discharged into the river on its north side amounts to 9,712,690 cubic feet, or 60,535,720 gallons; and that on the south side to 3,287,550 cubic feet, or 20,490,122 gallons: amounting together to 13,000,239 cubic feet, or 81,025,842 gallons; and *annually* to" the astounding and fabulous quantity of "29,574,432,330 gallons."

1037. The Commissioners, to whom was referred the consideration of the plans proposed by the Metropolitan Board of Works, (1045,) estimate the amount of sewage which daily pollutes the Thames from the metropolitan district alone at 15,249,777 cubic feet. This quantity, however, in consequence of the prospective increase of the population of the metropolitan district from 2,362,236 in 1851 to 3,979,089, will amount, estimating seven cubic feet of sewage per diem for each individual, to 27,853,623 cubic feet, or rather more than 170,000,000 gallons daily!

1036. Metropolitan and Town Sewage, by A. Sayer, M.D. London, 1857, pp. 3, 23, 25, 45.

1038. The pollution, however, of the Thames neither begins nor ends with the metropolitan district. From Banbury on the north, from Circencester on the west, from Godalming on the south, to the German Ocean on the east, the river is one vast sewer.

1039. The sewage of large towns and cities consists of refuse animal matters, of the excrementitial discharges of the inhabitants and of myriads of the lower animals, of the blood and animal fluids from slaughter-houses, knackers' yards, and tan-pits, of the foul and contaminated waters from gas-works, factories, and other establishments, and of refuse vegetable matters in a state of decomposition from public markets and other places.

1040. It may be divided into *solid, liquid,* and *gaseous,* or *insoluble, soluble,* and *aeriform.*

1041. The first two consist of the phosphates, urea, uric acid, ammoniacal salts, and salts of potash, soda, lime, magnesia, alumina, &c.; the last of sulphuretted and carburetted hydrogen gases, of nitrogen and carbonic acid gas, free ammonia, &c.

1042. A portion of the *solid* or *insoluble* part of this reeking, poisonous, and feculent sewage, a compound of animal, vegetable, and mineral substances, and of which the specific gravity is 1·325, is deposited upon the mud of the river, where it becomes exposed, by the ebbing of the tide, for many hours daily to the influence of the atmosphere and the solar rays; the remainder is suspended in its waters.

1043. A large portion of the liquid and soluble sewage is carried away by excess of the downcast.

1044. The gaseous or aeriform is a most deadly poison, on

1040. Mr. Gurney's Report to the First Commissioner of Works on the state of the River Thames.

1041. On the Drainage and Sewage of London and of large Towns, their Evils and their Cure, by James Copland, M.D., F.R.S. London, 1857, p. 11.

1042. Mr. Gurney's Report.

which the pollution of the atmosphere, and, as a consequence, the production of disease, diarrhœa, dysentery, and cholera depends.

1045. It is now nearly three years since an Act was passed by the Legislature, for the prevention of the pollution, by sewage, of the river Thames. This Act provided that large intercepting sewers should be made for the purpose of diverting the sewage from the Thames. During this period various plans have been suggested to the "Metropolitan Board of Works," in accordance with the provisions of the Act, and by them submitted to the "Chief Commissioner of Her Majesty's Works and Public Buildings" for approval, by whom they were referred to a Committee of Engineers, Messrs. Galton, Simpson, and Bakewell. Amongst other plans proposed was one by Mr. Bazalgette, 22nd December, 1856, which contemplated the construction, at an outlay of 4,000,000*l.*, of huge sewers, for the purpose of conveying to Erith Reach the daily increasing amount of excrementitial sewage from our overgrown modern Babylon.

1046. The Commissioners, after six months' mature deliberation, report that "the proposed outfall in Erith Reach is objectionable, because it would not effectually prevent the sewage from returning within the limits of the metropolitan boundary; because it would have a deleterious effect on the health of the district; and because it would probably be prejudicial to navigation." They conclude by suggesting that "the best outfall on the north side is a place between Mucking Lighthouse and Thames Haven, in Sea Reach, and that the best outfall on the south side is Higham Creek, in the Lower Hope." The estimated cost of this extension of Mr. Bazalgette's plan is 5,437,265*l.*

1047. The question, however, is not so much what is to be done, as what is not to be done, with the sewage, not only of London, but of the whole of the United Kingdom, the streams

1045. "An Act for the better Local Management of the Metropolis," 18 and 19 Vict. cap. 120 (14th August, 1855).

and rivers of which are similarly polluted in the ratio of the adjacent population. That which applies to the river Thames applies equally to the rivers of all our large towns and cities. The Liffey has been denounced in the House of Lords by Lord St. Leonard's as "an absolute pestilence in the neighbourhood of Dublin, in consequence of its being made the channel for the whole sewage of that city." *Ab uno disce omnes.*

1048. Dr. Copland objects to this plan, that it will increase the evil it is designed to remedy, and that if the sewage of the metropolis be conveyed to the German Ocean by means of a prolonged sewer, the river will of necessity be diminished to one-half its present size, its mud-banks be exposed to solar and atmospheric influences, and that the production of malaria will, as a consequence, be increased in intensity and amount.

1049. He suggests that several ample tanks be provided on either bank of the river, and that the sewage be conveyed thither for the purpose of deodorization and disinfection by means of the cream or hydrate of lime, combined with wood or peat-charcoal, soot, or coarsely-powdered coke, for the purpose of retaining the ammonia; that the *fluid or watery portion thus disinfected and deodorized be returned to the river*, and that the *more solid parts be employed for agricultural and horticultural purposes*, of which they possess every requisite. (1041.)

1050. In reply to Dr. Copland's objection, it may be stated that the supply of fresh water is fully equal to the demand. It will be shewn (1061) that the various water companies abstract from the river 35,372,782 gallons of water daily, and that the amount of evaporation from the 2,245 acres constituting the bed of the river at London has been estimated at 4,170,000 gallons daily, (1055,) together amounting to 39,542,782 gallons. On the other hand, it has been computed that 800,000,000 gallons of fresh water, in a tolerable state of purity, derived from the various sources and tributary

1049. Op. cit. p. 24.

streams of the Thames, descend through Teddington Lock every twenty-four hours. The construction of the lock precludes the ascent or reflux of water below it. The only tributary streams above London Bridge, the waters of which may be said to be absolutely pure, are the Wandle and Bavely Brook.

1051. It may possibly be advanced that common *brick* sewers permit the percolation of a portion of their fluid, and the escape of a certain amount of their gaseous contents, whereby the surrounding soil becomes saturated and polluted. In the construction of sewers, therefore, it were much to be desired that some substitute of a more efficient kind, and better adapted for the purpose in view than bricks, could be devised.

1052. Mr. Gurney, in his Report to the First Commissioner of Works, suggests the *combustion of the noxious gases of sewers.* The attempt has been made to effect this both in this country and in Belgium, but, in every instance, it signally failed, in consequence of the large amount of atmospheric air with which the gases of the sewers were commixed, and of the very high temperature to which carburetted hydrogen, and all elements of combustion, whether gaseous or not, must be brought before they will ignite.

1053. As impure water and impure air are inseparable, we can readily understand that the River Thames must necessarily exercise a most baneful influence upon the salubrity of those towns east of Brentford through which it flows in its course to the sea. Its whole area presents *one large evaporating surface,* which exhales, day and night, incessant and vast volumes of vapour surcharged with the mephitic effluvia and impurities arising from animal and vegetable matter in all stages of decomposition, suspended in its waters or cast upon its banks, and of which the atmosphere is the ready recipient.

1053. Meteorology of London, by James Glaisher, 1855, p. 41.

In short, the Thames acts as a laboratory for the general diffusion of noxious gases, prolific in quantity and intensity in the ratio of the excess of the temperature of its waters over that of the superambient atmosphere.

1054. It has been ascertained by Mr. Glaisher that the amount of water evaporated from the surface of water exceeds 30 inches in depth annually.

1055. The bed of the River Thames at London is estimated approximately at 2,245 acres; therefore, $2{\cdot}5 \times 43{,}560 = 108{,}900$ *cubic feet*, and $\frac{108{,}900}{0{\cdot}1605} = 678{,}505$ *gallons of water* evaporated in *one year* from *one acre* of water; which gives $108{,}900 \times 2{,}245 = 244{,}480{,}500$ *cubic feet* $= 1{,}523{,}242{,}991$ *gallons* evaporated *annually*, or 4,170,000 *gallons*, or about 18,000 *tons*, of water raised *daily* from the surface of the 2,245 acres of the polluted Thames at London, and diffused through the atmosphere of the city and immediate neighbourhood.

1056. During calm, clear weather, these emanations, consisting of sulphuretted and carburetted hydrogen gases, of nitrogen and carbonic acid gas, free ammonia and other vapours (1041), ascend high into the atmosphere, where they become generally diffused, but in their descent on cooling they spread broad-cast the seeds of disease and death; but during cloudy, moist weather, and particularly during calms, and the colder air of night, they are condensed into haze, mist, or fog, and occupy the lowest districts, the inhabitants of which are the earliest and the most numerous victims.

1057. Mr. Glaisher observed that for three weeks previous to the outbreak of cholera in London, in June, 1854, the temperature of the water of the Thames had gradually increased, and that when it had attained to 60°, and the atmosphere had

1054, 1055. Report on the Mortality of Cholera in England 1848, 1849. Published 1852, p. 60.

1056. Glaisher, op. cit. p. 46.

1057. Ibid. p. 100.

consequently been polluted by the vaporous emanations given off by the river, diarrhœa and cholera burst forth; and, that when the temperature of the river fell below 60°, these disorders declined, and ceased altogether.

1058. The *annual average* temperature of the Thames is 51·7°. The *mean daily* temperature is frequently, and for a lengthened period, considerably in excess of the minimum temperature of the atmosphere; but this more especially obtains *at night.* The excess on the night of September 12th, 1854, attained to 22·95°.

1059. The greater the difference between the temperature of the water and that of the air, the more dense will be the mist or fog.

1060. It may be laid down, if not as a law, at least as a general rule, that when the temperature of the waters of a river in a state of putrefactive foulness exceeds 60° Fahr., the minimum temperature of the atmosphere being below this, diarrhœa and cholera will ensue, and will continue to increase in amount and severity in the direct ratio of the increased temperature; and that when the temperature of the waters of the river falls below 60°, so will these disorders begin to decline, and will cease altogether.

1061. Of the waters of the Thames, taken for the most part above Hammersmith, and filtered previous to distribution, 138,053 houses were daily supplied, in 1856, with 35,372,782 gallons for culinary and domestic purposes!

1062. The impurities, mechanical, organic, and inorganic, of the waters of the Thames, its unfitness for culinary and domestic purposes, and its tendency to produce disorder and disease, will be treated of in Book II., under "*Foods and Drinks.*" It may suffice for the present to observe, that the

1058. Glaisher, op. cit. p. 46.

1061. Sayer, op. cit. p. 20.

1062. On the Chemical Composition of the Metropolitan Waters during the year 1854, by Dr. R. D. Thompson, p. 180.

water of the River Thames, collected at Chelsea and near Hungerford Bridge, in August 1854, was "turbid, opalescent, of a yellow colour, and disagreeable taste and smell, and teemed in abundance with dozens of species belonging to different classes and orders of living organic productions. It also contained the débris of food derived from the waterclosets and sewers of the metropolis, and certain species of diatomaceæ, found only in brackish water."

1063. As instances of the intensity and activity of the poisonous nature of the emanations arising from *sewers*, *drains*, and *cesspools*, the following may be adduced.

1064. In August 1852, an attempt was made "to improve the sanitary condition of Croydon," by the introduction of a system of tubular underground drainage, "with syphon-traps for the escape of foul gas." "The pipes were too small, the joints were not water-tight, and admitted air out, and water in." "Much water, loaded with the disgusting part of house sullage, was at first, during the whole day, visibly admitted to the river, and afterwards to the ditches of the adjoining fields," causing a most intolerable nuisance.

1065. This impotent and abortive attempt at "sanitary improvement," by converting a river into an open common sewer, was attended with and followed by an alarming outbreak of fever, diarrhœa, and dysentery.

1066. "Out of a population of 16,000 persons, there occurred 1,800 cases of fever, with a mortality of *sixty*, and *very numerous cases* of diarrhœa and dysentery, with a mortality of *ten*."

1067. The gentlemen upon whom devolved the duty of inquiring into the cause of this epidemic, reported that they "regretted to state the result of their investigations was a

1064. Reports of Neil Arnott, Esq. M.D., and Thomas Page, Esq. C.E. on an Inquiry ordered by the Secretary of State relative to the Prevalence of Disease at Croydon. Presented to both Houses of Parliament by Her Majesty's command. London, 1853, p. 7.

conviction that the *operations of the plan for the sewerage had been influential in producing the disease!*"

1068. In October, 1845, it was found necessary to empty a huge cesspool situate in the centre of a large mansion occupied by several families. Within three hours after the opening of the cesspool, one member, and speedily afterwards five others, of one of the families, was attacked with vomiting and purging. Of the other families, eighteen were attacked with diarrhœa and dysentery, of whom one, a celebrated and highly-gifted physician, died on the third day after the opening of this pestiferous pit.

For months afterwards diarrhœa and dysentery fastened upon every family who took up their residence within this malarious mansion. The evil was eventually remedied by filling up with quick-lime the pit, over the mouth of which the watercloset of the house was placed. The trap of this was now discovered *to be defective, permitting the constant escape of the poisonous emanations of this pest-hole.*

1069. "Four or five individuals were attacked with typhus fever after having transacted business in a nobleman's kitchen which had been inundated with a filthy fluid."

1070. "During the cleansing of the drains of a gentleman's house, the inmates were seized with *typhus fever*." "Four individuals were attacked by *typhus fever* during the clearing of a dirt-hole in another gentleman's house, of whom the latter fell a victim to the disease."

1071. Two of the servants of a gentleman's family residing on an elevated and peculiarly healthy locality became the subjects of intermittent fever, and one other of remittent fever, in consequence of the bursting of a drain which ran beneath the floor of the butler's pantry.

To multiply further these evidences were mere waste of time and space. The facts are incontrovertible.

1069. Armstrong, op. cit. p. 535.
1070. Ibid. op. cit. p. 535.

1072. When, however, we consider the amount of eremacausis, and of putrefaction of animal and vegetable matters, constantly taking place on almost every point of the habitable globe, the question naturally obtrudes itself, How comes it the whole atmosphere is not polluted by their miasmatic gases to an extent to render it poisonous and unfit for sustaining animal life?

1073. Nature has mercifully supplied us with a natural and abundant disinfectant *ozone*, (331,) the office and property of which appear to be to destroy all oxidisable mephitic emanations and miasmatic exhalations with which the atmosphere is constantly contaminated, and thus to preserve and sustain its purity unsullied.

1074. The quantity of ozone necessary to purify miasmatised air is exceedingly minute.

1075. From experiments instituted by Schönbein, it appears that atmospheric air, containing but $\frac{1}{3240000}$ of ozone, is capable of disinfecting its own volume of air loaded with the miasmata given off in one minute by 4 oz. of flesh in a high state of putrefaction.

1076. Atmospheric ozone in destroying oxidisable miasmata suffers destruction in its turn. This is one of the reasons why ozone, though continually engendered, cannot accumulate in the atmosphere to an extent which would be prejudicial to animal life. (341, 342.)

1077. During the cholera visitations in 1849 and 1854, the absence of ozone on the water-level, and in low-lying districts, was constantly noticed and recorded. It must not, however, be supposed because the presence of ozone was not evidenced by the ozonometer, that none was generated in these low situations equally with more elevated localities. The explanation is to be found in the fact, that in effecting the decomposition of the malarious emanations of these low districts, the ozone was

1075. Schönbein, Med.-Chir. Trans. vol. xxxiv. p. 205.

expended and suffered destruction in its turn. As, however, malaria, in all its intensity, was rapidly and abundantly evolved, and as the electrical action of the atmosphere during these periods was comparatively feeble, not to say inert, it resulted that ozone was not generated in a corresponding degree, or in quantity sufficient to neutralise the fearfully large amount of miasmatic gases, *of greater specific gravity than the atmosphere itself,* constantly exhaled into it. This interpretation will also explain its presence, though in small quantity, on higher ground, and its greater abundance at considerable elevations, and will equally account for the greater virulence and mortality of the cholera in low districts, and its diminishing intensity in the ratio of elevation. (961, 962.)

If, therefore, the quantity of miasmatic gases given off exceed the quantity and quality of the ozone formed at the same time, some kind of epidemic will, to a greater or less degree, prevail.

1078. Of all seasons of the year *winter* is that in which the atmosphere abounds with ozone, and is most free from oxidisable miasmatic matters.

1079. The higher strata of the atmosphere are more ozoniferous than the lower, and contain less oxidisable miasmatic matter than those which are nearer the surface of the earth.

1080. *Disinfectants.*—If nature have bountifully supplied us with her own universal disinfectant ozone, art has contributed her share in providing us with many powerful antiseptics, disinfectants, and deodorisers. Of these are the various compounds of chlorine, chloride of soda, of lime, and of zinc, hypochlorite of potassa, or chloride of potassa, and chlorinated potassa, and hypochlorite of soda (*Labarraque's disinfecting fluid*), sulphurous acid, the vapour of nitric and of muriatic acid, oxygen, kreosote and magnesia, and various other substances.

1081. Chlorine (from χλωρὸς, *green*) is a yellowish green-coloured gas, of an astringent taste, and disagreeable odour.

It is one of the most suffocating gases, and excites spasm and great irritation of the glottis when respired, even though considerably diluted with atmospheric air. Its specific gravity, according to Davy, is 2·395.

Chlorine has a very strong attraction for hydrogen, and is indirectly one of the most powerful oxidising agents which we possess. It decomposes and resolves into harmless products the organic matters of which infection and contagion appear to be composed, and renders innocuous, by seizing on their hydrogen, the volatile principles given off by putrefying animal matter.

1082. The compounds of chlorine, on exposure to air, absorb carbonic acid gas, and evolve chlorine.

1083. Mr. Condy, of Battersea, has recently introduced to the notice of the profession and of the public *"a disinfectant fluid,"* of which the chief constituent is *"condensed oxygen."* It is said not only to deodorise and disinfect perfectly, but also to destroy absolutely the cause of infection. It possesses one most important advantage over chlorine, that it is not poisonous, does not evolve any noxious or unpleasant smell, and may be employed to purify water. In short, it is a near approximation to ozone, and promises entirely to supersede chlorine as a disinfectant. It is favourably noticed by the Board of Health as *"a true disinfectant."*

1084. Disinfectants are useful in destroying the mephitic and noxious emanations of drains, urinals, privies, cesspools, stables, and cattle-sheds, and the contagious and infectious matter of sick rooms and hospitals.

1085. It is self-evident that the influence exercised by disinfectants must be of an exceedingly limited nature, of a purely local character, and of a very ephemeral duration.

1086. As a *general disinfectant and deodoriser, the cheapest, the simplest, the most powerful, and most effectual,* is PURE FRESH AIR.

No miasm can withstand a free dilution by atmospheric

air. No epidemic, pestilential or otherwise, can linger amidst aerial currents of greater or less vehemence; but in calms and stagnant atmosphere disease and pestilence stalk forth and count their victims by the thousand.

1087. It is obvious from that which has preceded, that in our private dwellings, our barracks, hospitals, and union houses, too much care cannot be paid to the *arrangement* and *construction* of the drains, nor too much thought be bestowed on the drainage generally. The drains, where possible, should communicate, at a proper fall, with the common sewer; they should consist of glazed earthen tubes, or of iron pipes, well and carefully cemented together: *brick* barrel or square drains are highly objectionable, in consequence of the porous nature of the material of which they are constructed. The drains, which should not pass through the house, should be flushed twice, or at least once in every week. With this view there should be an *ample supply of water*, averaging at the lowest calculation seven cubic feet = 43·67 gallons per day for each inmate.

But, above all, it is most important that the drains be in good order; that there be no leakage of their fluid contents, nor escape of foul air, and that the traps of the closets be in perfect repair. If the drains of the house communicate with the common sewer, it is imperative that one or more "*dip*," or other kind of traps, be placed near the communication, in order to prevent the emanations of the sewer finding their way into the house on occasions of high winds or tides.

1088. The surface drains of the streets, of courts, alleys, yards, and stables, should be placed under the surveillance of an officer, part of whose occupation should be to see that the scavenger does not neglect his duty.

The gratings of the surface drains should not be trapped with a view to prevent the escape of noxious emanations generated within the sewers; they should be left open, to allow the free entrance of atmospheric air to dilute their

poisonous exhalations. Were the contrary course to be pursued, these fœtid and mephitic gases would find their way, in the highest state of concentration, into every house the drains of which communicate with the common sewer.

1089. Cesspools and soil-pits, unless steined and cemented, should be prohibited, lest their fluid contents saturate the soil, and contaminate the adjoining wells.

1090. In almost all large towns, companies for the supply of pure water to the inhabitants have been formed. Were it rendered *compulsory* where these exist, and the water-supply is adequate to the wants and requirements of the population, that every house, tenement, stable, and manufactory should derive their water from these sources, irrespective of public or private wells, it would go far to improve the sanitary condition of towns and districts. Rival companies would vie with each other in supplying the inhabitants at the least possible cost, which, if found necessary, might be fixed or regulated by the local government; or the water might be supplied by this latter, and the attendant expense levied on the householder in the form of a tax based on the assessment to the poor's rate. In any case, an inspector should be appointed to ascertain that the supply is equal to the demand, that the source is pure, and the water uncontaminated. These duties might devolve on the "medical officer of health," the highway surveyor, or the officer above suggested.

1091. It were well for the community at large if the provisions of the Act before referred to (1045) were extended to all large towns. Sewers would then be constructed before houses were built; underground apartments would be efficiently drained; an abundant supply of pure water would be ensured; but, above all, our rivers would not be converted into open sewers, or their waters polluted and poisoned by the excrementitial discharges of house-drains, the blood of slaughtering-houses, or the garbage and offal of the towns through which they flow. The air would not be loaded with noxious

and pestiferous emanations; the atmosphere of the city would be little inferior to that of the village, the denizens of the former might compare with the rustics of the latter; debility, dyspepsia, glandular disease, and consumption would not, *par excellence*, fasten on the offspring of the citizen; remittent and typhus fevers would be driven from their stronghold; diarrhœa and dysentery would be reduced to their normal proportions, and pestilential cholera would strive almost in vain to find a resting-place for the sole of its foot.

CHAPTER V.

VENTILATION.

1092. We have been already told that the healthiness of seasons in unhealthy climates depends very considerably on the due ventilation of such localities by powerful and regular winds, and that towns and districts are rendered healthy, or otherwise, in proportion to the amount received by them of these purifying influences. (974.) We have also been officially informed of the salutary effects resulting from the admission of free ventilation to our military stations in the West Indies, by the cutting down and removal from their immediate vicinity of all superabundant vegetation, rank grass, and brushwood, in which malaria is prone to become entangled. (975, 976.)

1093. We have now to enter upon the importance of extending these principles to our dwellings, our hospitals, gaols, barracks, union houses, factories, churches, theatres, and all other public buildings in which large numbers of persons assemble or are congregated together. It is not our province so much to enter into the mode in which this is to be effected, as to discuss the principle itself, to inculcate the importance of observing a more natural, and consequently a more rational, system of ventilation, with a view to the promotion of health, the prevention, mitigation, or arrest of disorder and disease.

1094. The objects of ventilation are—

> *a*. To expel all poisonous and infectious gases from our dwellings, whether the products of combustion, respiration, or overcrowding, or the emanations of drains, sewers, and cesspools, or of putrescent animal and vegetable matter.

b. To equalise the temperature and remove all excess of, and supply any deficiency in, the aqueous vapour of the atmosphere of our dwelling or sleeping apartments.

1095. The paramount necessity of due ventilation, whether in our private dwellings, public buildings, or in large assemblies of persons, will be self-evident, when we bear in mind that a healthy adult man inspires 24,000 cubic inches of air in an hour, or 576,000 in twenty-four hours, and that the expired air is found to have *lost* from 4 to 6 per cent. of its *oxygen* and to have *acquired* from 3·5 to 5 per cent. of *carbonic acid gas*. (852, 849.) Assuming that the expired air contains 4 per cent. only of *carbonic acid*, he would evolve 960 cubic inches per hour, 23,040 in 24 hours = 3,529 grains, or 7 oz. 2 drachms, 49 grains of carbon. (853.) In addition, however, to the amount of carbon thus given off by the lungs, we must take into calculation that exhaled by the cutaneous surface, amounting, according to Scharling, to one-fifth of an ounce per day = 576 cubic inches of carbonic acid gas; and, according to Dalton, to one-fourth of an ounce of carbon = 720 cubic inches of carbonic acid gas.

1096. Other sources of contamination of the atmosphere exist in the *pulmonary transpiration*, and in that exhaled by the "*twenty-eight miles* of perspiratory tube, terminating in *seven millions* of pores on the surface of the skin."

1097. The *maximum* amount of this, the *insensible cutaneous perspiration*, including the former, *the pulmonary transpiration*, has been estimated by Lavoisier and Seguin at 25·6 grains, troy, per minute = 3 ounces, 1 drachm, 36 grains per hour; or 6 pounds, 4 ounces, 6 drachms, 24 grains in twenty-four hours. The *minimum* quantity has been calculated at about one-third this amount, viz. 8·8 grains per minute = 2 pounds, 2 ounces, 3 drachms, 12 grains, in twenty-four hours; and the *mean* at 18 grains per minute = 4 pounds, 6 ounces.

1097. Müller's Physiology, by Baly, vol. i. p. 626.

1098. The *pulmonary mucous membrane* is said to exhale 7 grains per minute = 21 ounces in twenty-four hours. Menzies calculated it at 2,880 grains = 6 ounces, Abernethy at 4,320 grains = 9 ounces, and Lavoisier at 13,704 grains = 28 ounces, 4 drachms, 24 grains. The *average* amount may be estimated at 3 grains per minute = 9 ounces in twenty-four hours. (906.)

1099. The *insensible cutaneous transpiration* averages, according to Lavoisier and Seguin, 11 grains per minute = 33 ounces in twenty-four hours, an amount nearly equal to the renal secretion. As, however, this depends so materially on the temperature and hygrometric condition of the atmosphere, it were better to take a lower estimate, 8·8 grains per minute = 26 ounces, 3 drachms, 12 grains in twenty-four hours.

1100. An atmosphere saturated with moisture interferes with the cutaneous and pulmonary exhalations. In dry weather both are increased twofold.

1101. Adopting this calculation, the sum of both secretions, the *cutaneous and pulmonary*, would amount to 2 pounds, 11 ounces, 3 drachms, 12 grains in twenty-four hours.

1102. The *cutaneous exhalation* is a *true secretion* from the blood, somewhat analogous to that of the urine, of those matters which, at the temperature of the body, are capable of assuming the gaseous form, such as carbonic acid and water. It varies before and after meals, and is at its maximum immediately after dinner.

1103. The *pulmonary transpiration*, on the contrary, is, according to Mr. H. Milne Edwards, the *effect solely of evaporation.* Its amount is diminished in the ratio of the moisture of the atmosphere.

1104. *Human perspiration*, according to Thénard, is composed of a large quantity of water, a small proportion of free acetous acid, muriate of ammonia, soda and potash, an atom

1104. Ann. de Ch. lix. 262.

of phosphate of lime and oxide of iron, and an inappreciable quantity of animal matter closely resembling gelatine. The relative proportion of solid matter to that of the water varies from 0·5 to 1·25 per cent.

1105. The *deterioration* sustained by the atmosphere during respiration, by the *loss* of its *oxygen,* and by the *contaminations, heat,* and *effluvia* effected by the *addition* of the *pulmonary* and *cutaneous* transpirations, and by the *carbonic acid gas* exhaled into it by the lungs and skin, is further aggravated in artificially illuminated and heated rooms, by the *products of combustion evolved,* and by the loss of the *oxygen consumed* by the various sources of artificial light and heat.

1106. The atmosphere of a room thus vitiated, rendered fouler and less capable of sustaining life with each breath drawn, speedily becomes unfit for continuing combustion or supporting animal life. Lamps and candles burn dimly, the flame is elongated, and yields a reddish and much diminished light; whilst man himself, overwhelmed with the *accumulated heat and impurities of the atmosphere,* pants for that oxygen which has been already consumed, but not re-supplied, at least not in quantity sufficient to support life, and swoons away.

1107. The contamination of the atmosphere consequent upon artificial lighting and heating depends, not so much on the nature of the material consumed, or on the amount of oxygen burned, as on the *products* of *combustion,* carbonic acid gas, water, and sulphurous acid.

1108. The insalubrity of the air is *in the ratio of the carbonic acid diffused through it.* If this exceed a half per cent. the atmosphere, according to Leblanc and Péclet, is positively injurious, *not,* however, *from the mere deficiency of oxygen,* but from the actual deleterious action of the carbonic acid gas. Drs. Reid and Arnott give a much lower limit. Dr. Roscoe

1107. Brande, op. cit. p. 500.

1108. Journal of the Chemical Society, vol. x. p. 251.

considers it "premature to say that the smallest increase above the normal amount is not productive of harm."

1109. Too large or too small a quantity of aqueous vapour dissolved in the atmosphere of a closed room necessitates a supply of fresh air.

1110. In order that we may form some idea of the amount of contamination and deterioration of the atmosphere produced by the combustion of gas, oil, wax, &c., and by open coal fires, it may not be irrelevant to our subject to consider these subjects separately.

1111. *Coal Gas.*—One pound of this gas = 16 ounces, contains 0·3 lb. of hydrogen, and 0·7 lb. of carbon, and when burned *consumes* 4·26 cubic feet of oxygen, equal to the quantity contained in 19·3 cubic feet of atmospheric air, and *produces* 2·7 lbs. = 43 ounces of *water*, and 2·56 lbs. = 40 ounces of *carbonic acid gas*, besides *sulphuric* and *sulphurous acids.*

1112. An argand burner, yielding a light equal to six wax candles, will consume from four to five cubic feet of gas per hour, and will *require* from 40 to 50 cubic feet of atmospheric air, or from 8 to 10 cubic feet of pure oxygen, to effect its combustion, and will *produce* from 4¼ to 5¼ cubic feet of *carbonic acid gas*, and from 4½ to 5½ pints of *water.*

1113. If an argand gas-light be suspended in a room 12 feet square, and 12 feet high, the windows, doors, and fireplace being closed, it would, in three hours, contaminate the atmosphere to an extent which would render it injurious to animal life.

1114. *Oil.*—One pound of the best sperm oil = 13 ounces, contains 0·12 lb. of hydrogen, 0·78 of carbon, and 0·10 of oxygen, and when burned in an argand lamp *robs* the atmos-

1111. Brande, op. cit. p. 499.

1112. Ure's Dictionary of Arts and Manufactures, p. 845. Williams on Combustion, ch. v. p. 23.

1114. Brande, op. cit. p. 499.

phere of the oxygen contained in 13·27 cubic feet = 2·93 cubic feet, and *produces* 2·86 lbs., or nearly 3 lbs. of *carbonic acid gas,* and 1·06 lbs. = 20 ounces of *water.*

1115. A well-trimmed argand burner, one inch in diameter, yielding a light equal to ten or eleven spermaceti candles of six to the pound, each consuming 140 grains of spermaceti per hour, will *burn* about 800 grains of oil *per hour,* (= 1 lb. in about eight hours,) and will *require* 1·658 cubic feet of atmosphere, or 0·366 cubic feet of pure oxygen, to effect its combustion, and will *produce* 0·357 lb. of *carbonic acid gas,* and 0·133 lb. of *water.*

1116. *Wax.*—One hundred pounds of wax consist of—

Carbon	81·784
Hydrogen	12·672
Oxygen	5·544
	100·000

and when burned *require* 313·922 lbs. avoirdupois of oxygen, equivalent to 18,543·0 cubic feet of atmospheric air, and *produce* 299·874 lbs. of *carbonic acid gas,* and 114·048 lbs. of *water.*

1117. One candle, six to the pound, will consume 134 grains of wax per hour. Forty-three candles will, therefore, consume one pound of wax during the same period.

1118. *Coal.* One hundred pounds of Elgin and Wallsend coals consist of—

Carbon	76·09
Hydrogen. . . .	5·22
Nitrogen	1·41
Sulphur	1·53
Oxygen	5·05
Ash	10·70
	100·00

1116. Gay Lussac, Thénard, Phillips.

1117. Brande, op. cit. p. 499.

1118. Cyclopædia of Useful Arts. Tomlinson.

and *require*, for combustion, 241·14 lbs. of oxygen, equivalent to that contained in 14,243·9 cubic feet of atmospheric air.

1119. As the products of the combustion of coal, carburetted hydrogen, carbonic acid and sulphurous acid gases, and water, escape, for the most part, by the flue of the chimney, and do not add to the contaminations of the atmosphere of the room, it is perfectly unnecessary to enter into any detail on the subject of their respective amounts. It is sufficient to shew the large amount of deterioration of the atmosphere effected by the *consumption of its oxygen in the combustion of the coal*, and the large supply of fresh air which this necessitates.

1120. As, however, the quantity of coal consumed, in consequence of varying draught, is never twice alike in the same house, or even in the same stove, we can but attain to an approximative amount of the consumption of oxygen by open coal fires. It has been shewn above that every ten pounds of coals requires 120·57 pounds of oxygen = to that contained in 1,575·55 feet of atmospheric air. Let us assume that the atmosphere is robbed of only *half* this amount of oxygen, and we shall readily admit the necessity of free ventilation, and the admission of pure air.

1121. It has been estimated by Dr. Arnott that each adult individual vitiates, *per minute*, by respiration, 400 cubic inches of air, and by pulmonary and cutaneous transpiration, three cubic feet. The fires, lamps, and candles are calculated by Mr. Tredgold to deteriorate at the rate of one-fourth of a cubic foot *per minute* for each individual. Hence it follows, that every individual, in a room artificially lighted and warmed, will require, at the least, three-and-a-half cubic feet of pure air per minute. Vierordt considers two and a half sufficient: Péclet thinks five cubic feet necessary: Dr. Reid is of opinion that the quantity should not be less than ten feet: Dr. Arnott and Dr. Roscoe consider this insufficient, and that at least

1121. Report of the Surveyor-General on the Construction, Ventilation, &c. of Pentonville Prison, 1844, p. 25.

twenty feet are necessary to each individual. In the model prison at Pentonville, "from 30 to 45 cubic feet of pure fresh air, varying from 52° to 60°, are made to pass into every cell in a minute." In our Houses of Parliament, 60 cubic feet per minute have been occasionally given to each individual.

1122. If the amount of impairment and vitiation of the atmosphere produced by *one* individual be multiplied by the number of persons congregated or assembled together, and that effected by *one* gas burner, lamp, or candle, by the number of artificial lights, a tolerably accurate estimate, due regard being had to the size of the building, will be formed of the amount of the combined deterioration, and of the supply of fresh air necessary to support life and sustain combustion.

1123. One or two examples will suffice:—Her Majesty's Theatre is capable of containing 3,000 persons, exclusive of the *troupe*, the orchestra, servants, and attendants. The number of gas and other lights amounts to 1,234. Admitting that, at the lowest calculation, (Vierordt's,) each of the spectators, including the lights, requires only two and a half cubic feet of fresh air *per minute*, (1121,) it results that the enormous amount of *seven thousand five hundred cubic feet* of pure air must, or ought to, find ingress into the house *each minute*, for the sustentation of life, and the combustion of gas and other lights, and an equal quantity of vitiated atmosphere must find an escape during the same brief space of time. If, however, the highest calculation hold good, (that of Dr. Arnott and Dr. Roscoe,) (1121) the quantity of fresh air which ought to be admitted, and the amount of deteriorated air which should escape, *each minute*, will amount to *sixty thousand cubic feet.*

1124. Some idea of the *amount* and *distribution* of the *impurity* of the atmosphere of a large assembly has been furnished by Dr. Roscoe. Of the atmosphere of a fashionable and crowded theatre, which had attained an elevated tempe-

1124. Journal of the Chemical Society, vol. x. p. 251.

rature from the combustion of gas and the respiration and exhalation of the audience, 10,000 volumes taken four feet above the stage contained 23·37 of carbonic acid gas, and a like quantity collected 30 feet higher contained 32·12 volumes of the same gas.

1125. At a meeting of the Chamber of Deputies, at Paris, of which the cubical dimension of the hall amounts to 180,000 cubic feet (English), 600 persons being present, and the amount of ventilation 396,000 cubic feet per hour = 11 cubic feet per minute for each person, Leblanc found the air flowing out was contaminated to the extent of one part, by weight, of carbonic acid gas in four hundred; an amount two and a half or three times greater than is contained in pure atmospheric air.

1126. In a closed room of the Wellington Barracks, of which the capacity is 7,920 cubic feet, 16 guardsmen slept from 9 p.m. to 3 a.m.; a low fire was kept burning in a common wide grate, over which was an open ventilator. In 10,000 volumes of the air of the room, collected 2 ft. 6 in. from the floor, Dr. Roscoe found 12·42 volumes of carbonic acid gas. The supply of fresh air was ascertained to be 13·3 cubic feet per minute for each man. On another occasion 20 men slept in the same room under similar circumstances, the result gave in 10,000 volumes 14·18 of carbonic acid gas.

1127. The free air of London, on a windy day, (27 February, 1857,) was found to contain 3·7 of carbonic acid gas in 10,000 volumes; that of Chambeisy, on the Lake of Geneva, was ascertained by De Saussure, as a mean of 17 experiments, to contain 3·8 in 10,000 volumes.

1128. Attempts have been made to calculate the number of cubic feet *in space* which are required for each individual, in order to maintain a healthy condition of the body. In private houses, especially in the bed-rooms, each individual should

1126, 1127. Journal of the Chemical Society, vol. x. p. 251.
1128. Medico-Chir. Trans. vol. iv. p. 115.

have not less than 500 cubic feet. Sir Gilbert Blane says that "in calculating the arrangements of an hospital, 600 feet is the smallest portion of space which ought to be allotted to each person;" and that "if it fall much below this, it will be found impossible to maintain a due purity of the air." "The portion of cubic space allowed to each patient in St. Thomas's Hospital was from 700 to 1,000 feet."

1129. The minimum amount of space which should be allotted to each patient in civil and military hospitals is 1,000 cubic feet. In the new wards of the *London Hospital* 1,700 cubic feet are calculated for each person. Slaves in slave-ships have, however, existed for weeks in a space of 14 cubic feet. The golden rule is to give to each individual as much space as possible, and to ventilate that space freely.

1130. In the Report of the Commission appointed by Her Majesty to inquire into the Sanitary Condition of the British Army, it is stated that in the metropolitan hospitals the average cubic space allotted to each bed is 1,434 feet, the largest space being 1,560 feet, and the smallest 800 feet; and that in the military hospitals the average space per bed is 632 feet, the maximum space in any ward being 1,143 feet, and the minimum 400 cubic feet.

1131. "In hospitals," says Sir Gilbert Blane, "irrespective of the generation and retention of infectious matter from defective ventilation, recoveries in all classes of patients are retarded by impure air." "This is especially true with regard to severe injuries, and the capital operations of surgery." "At the Leeds Hospital," we are told by Mr. Howard, "no case of compound fracture or trepan survived till the ventilation of the wards was improved." "The like remark may be made with regard to lying-in women and infants. If pure air is necessary to preserve the health of the most hale and robust, how much more must it be so when the powers of nature are

1131. Medico-Chir. Trans. vol. iv. pp. 113, 114.
Diseases of the Army, 1768.

weak?" "In short, without pure air the utmost professional skill would be unavailing." Sir John Pringle invariably found those hospitals most healthy in which broken windows and other dilapidations gave free ingress to pure air, and a ready exit to the vitiated atmosphere.

1132. Contamination and deterioration of the air of hospitals produces erysipelas, gangrene, or fever of a low and malignant type; of lying-in charities, puerperal fever; and of gaols, "gaol fever."

1133. In close, filthy, and ill-ventilated stables inflammation of the lungs, glanders, farcy, and grease are generated amongst horses; and in dirty confined kennels distemper is common among dogs.

1134. The rooms of our *dwelling-houses*, as a general rule, are too close, and very insufficiently ventilated. Too much care is bestowed in the endeavour to make floors, ceilings, windows, and doors air-tight. There is too great a dread of draughts and currents, and consequently too scant a supply of fresh and pure air. The secret of the avoidance of draughts consists not in excluding the open air, but in admitting it freely. In summer, when the difference of temperature between the outer and inner air is comparatively small, and when, as a consequence, the ventilation by chimneys and windows is less efficient than in the colder seasons, the housemaid "adds fuel to fire," by taking especial care to keep the flaps of the register stoves hermetically closed, lest the bright bars should be soiled by the descent of dust, soot, or rain-drops. In winter the windows are rarely opened. Carpets for floors, sand-bags for doors and windows, sash-fastenings and pegs, list, brown paper and paste, are all so many hindrances to free and perfect ventilation, and a constant source of the "smoky chimney," or of the "back smoke," which descends the unused flue, in order to supply the fire with that oxygen which we have exercised so much-ingenuity to shut out. Our carpeted bed-chambers are too small, overloaded with furniture, encumbered with bed-

hangings and window-curtains, and carefully provided with blinds and shutters, to exclude the pure air and light of heaven. In addition, the fire-place is frequently kept closed, or is blocked up by chimney-boards, or bags of straw, "in order to prevent a downward draught." In the attics and upper chambers fire-places are often altogether wanting.

1135. The Report of the Commission to which reference has been already made (1130) lays great stress on "the fetid and unwholesome atmosphere of the barracks in which the men of the Foot Guards sleep, the habitual breathing of which, though producing for the most part no direct immediate effects, probably lays the seeds of that pulmonary disease which is so fatal to the British army."—*Vide* 1126, 1121.

1136. This is scarcely a fair representation of facts, as it would lead to the inference that this vitiation of the atmosphere arises *of necessity* (*vide* 1126), and that it predisposes to phthisis. Every medical officer knows that the habits and prejudices of the soldier render it next to impossible to ensure that amount of ventilation of which the arrangements of his hospital admit. Every adjutant will echo this so far as barrack and guard-rooms are concerned. It is notorious that the soldier in hospital, in barrack, and in the guard-room, will, in spite of the utmost vigilance, close every aperture, even to the key-hole, against the external air. The disease of the soldier is set down to the system, to the severity of his duties, and to the utter disregard, by his officer, of his comfort and his health. How severe soever the duties may be, neither the first nor the last holds good. The "young agriculturist of 19," fresh from his native village in the weald of Sussex, or the fens of Lincolnshire, suddenly finds himself a guardsman, in the midst of the allurements and debaucheries of a London life. Of these he tastes but too freely, as the "hospital returns" testify. His duties are severe; the discipline adds to their severity. If, having been recently dismissed the hospital, he come off sentry, his great coat saturated with rain, and enter the pestiferous

atmosphere of an over-heated guard-room, of which every crack and cranny is stuffed with paper to make it if possible air-tight, he first roasts himself before a huge fire, and next lies down to sleep on the guard-bed, without being permitted so much as to unhook a hook, or unbutton a button of his wet great coat, much less to take it off, lest the guard should be "turned out." In the midst of a profuse perspiration this occurs, or he is "told off" to form one of the relief, and to take again his two hours' tour of duty, may be, to be posted in some unsheltered part of St. James's Park, or on the ramparts of the Tower, exposed to all the severities of a cold north-east blast, and perhaps, in addition, to the noxious emanations of the Thames, or the Tower ditch (1056, 959).

1137. Doubtless all these are evils to be looked into and to be remedied; and here too may lie the very *fons et origo* of that "English disease," *consumption*, which in the report is charged to the "fetid and unwholesome atmosphere," during sleeping hours, of the barrack-room.

1138. So lately as 1830 the men of the battalion furnishing the "king's guard" invariably appeared during the *winter months* in white, pipeclayed trousers, whilst other guards were mounted in the grey cloth trousers. Upon the representation of the medical officers of one of the regiments, his Grace the late Commander-in-Chief the Duke of Wellington directed that this absurd and dangerous practice should be discontinued.

1139. The mortality of the army has been contrasted with that of the country generally, and it has been stated in the report, on the authority of the Registrar-General, that, of effective men of all ages of the army at home, the annual mortality in the thousand is 17·5, while in the general population it is, for men of the army ages in the town and country 9·2, and in the country alone 7·7.

1140. This fearful difference is to be sought, not in the "fetid and unwholesome atmosphere of the barrack-room," not

in the limited and narrowed hospital breathing-room, not in the "boiled beef," on which the Life and Horse Guards live and fatten, and on which the Guards are said to pine, and fade, and die, but on the more severe duties of the latter, as compared with the Household Cavalry Brigade and the Line. The duties incident to a West India colony are less severe than those of a battalion of Guards doing duty in the Tower of London, within the morbific influence of the mephitism of the river Thames.

1141. Let the guard-room, the barrack, and the hospital be *effectually* ventilated and objectional offices removed; let the severity of the duties of the Guardsman, when possible, be lessened; let the discipline of the guard-room be relaxed when urgent necessity appears to demand it; let the diet of the soldier be varied, and the Thames no longer converted into a common sewer, and we shall find that the health of the Guards and of the army will compare, *cæteris paribus*, with the civil population of the united kingdom.

1142. It is, however, in the habitations of our poorer brethren that the results of deficient ventilation, or of its total neglect, are witnessed in all their concentrated virulence and intensity. Dr. Letheby, the officer of health of the City of London, states, in his "*Report on the Sanitary Condition of the City of London*," for the quarter ending March 28, 1857, presented to the Commissioners of Sewers, that in some of the rooms of the haunts of filth and misery which it was his duty to visit, he found "the atmosphere so close and unwholesome, infested with that peculiarly fusty and sickening smell so characteristic of the filthy haunts of poverty," that he "endeavoured to ascertain by chemical means whether it did not contain some peculiar product of decomposition, to which might be attributed its foul odour and its rare power of engendering disease." He "found that it was not only deficient in the due proportion of oxygen, but that it contained *three times the usual amount of carbonic acid*, besides a *quantity of aqueous*

vapour charged with alkaline matter that stunk abominably, doubtless the product of putrefaction and of the various fetid and stagnant exhalations that are given off from the unclean human body, and a pestilential source of disease, the consequence of heaping human beings into such contracted localities."

1143. Dr. R. Angus Smith, of Manchester, in his experiments on the *air and water of towns*, has demonstrated that the condensed air of a crowded room yields a deposit of a thick glutinous mass, having a strong animal odour. This deposit becomes, in a few days, converted into a *vegetable growth*, which is followed by the production of *multitudes of animalcules.*

1144. Dr. R. D. Thompson says, "*organic living bodies* constantly surround us in close apartments, and animal matter, under certain circumstances, exists in the air."

1145. If, therefore, it be true, as has been stated before, on the authority of Sir Gilbert Blane, (914,) that "it seems to be a general law of animal nature, at least among the *mammalia*, that the accumulation and stagnation of the exhalations of the living body generate fever and disease," there is little difficulty in explaining the large amount of disease and mortality observable in the habitations of the poor, as a consequence of the impurities of the air of their dwellings and the exhalations from their bodies not being promptly and efficiently carried off by due ventilation, and of the amount of oxygen consumed not being adequately supplied by the admission of a proportionate quantity of fresh air.

1146. The question next arises how is the atmosphere of rooms and buildings, rendered unfit for the purposes of respiration and combustion, to be resupplied, and how is the vitiated air to find an escape.

1147. Respired air, being specifically lighter than pure cold

1144. Lancet, January 19, 1856.

atmospheric air, ascends with the heated effluvia towards the ceilings and upper parts of dwelling-rooms and sleeping apartments, where it becomes condensed and subsequently descends, commixes with and contaminates *equally*, in accordance with the laws of the diffusion of gases (11), the *whole air of the room.* A portion escapes by the upper parts of the closed doors, and by the crevices and openings between the window-frames and sashes, but by far the larger part is rapidly carried off by the flue of the chimney. This is the most powerful ventilator of the room, and continually abstracts and removes a large stream of heated and vitiated air sufficient to change the entire atmosphere of the room, provided there be an average amount of *open* doors, windows, and crevices to yield a corresponding supply of pure air.

1148. The fresh air enters by the windows, doors, and crevices. It has been estimated that eight cubic feet of air will pass per minute between each window-frame and the sashes. But, as this supply of fresh air has to be equally divided among the occupants of the room, it has been found that in crowded school-rooms, dormitories, barracks, and other places, this natural or accidental ventilation scarcely affords four feet per head per minute, a quantity sufficient, doubtless, to sustain life, but not to preserve rude and vigorous health.

1149. Dr. Roscoe has shewn that the beneficial action of the *brick and mortar walls* of our dwellings is not confined to the mere absorbing from or restoring moisture to the atmosphere, but that it extends to a very large diffusive interchange between the carbonic acid gas of the apartments and the external atmosphere; that, in fact, *brick walls* are powerful aids to ventilation. Dr. Roscoe ascertained that in a closed space, the air of which contained 16 per cent. of carbonic acid gas, 3·25 per cent. escaped in two hours through the solid brick.

1150. The unhealthiness of iron, or new and damp houses,

1149. Journal of the Chemical Society, vol. x.

is probably partly accounted for by the absence of all diffusive interchange through iron and through wet walls.

1151. Newly-built houses, and houses how long soever they may have been built, though exposed for years to the action of dry air, are unhealthy when first inhabited. The lime of the dry hydrate of the mortar of their walls combines with the carbonic acid abundantly supplied by the lungs and skin of their first occupants, and parts with and sets free as moisture the 24 per cent. of water chemically combined with it. The water thus displaced speedily evaporates and saturates the atmosphere of the various rooms, its excess being condensed in drops on the windows and cold walls. This does not depend on ordinary moisture or dampness of the walls, but on the retained water of the hydrate, and must invariably occur on the first occupancy of any building into the walls of which lime enters as a component.

1152. Liebig suggests that in close rooms and on shipboard deficient ventilation may be compensated for by the use of hydrate of lime. Eighteen or twenty pounds of slaked lime will absorb 38 or 39 cubic feet of carbonic acid gas, which would be immediately replaced by an equal volume of fresh air entering through the crevices.

1153. From all that has preceded it would appear that that against which we have the most to be on our guard in our *private dwellings* is the emanations of cesspools, drains, and sewers, and *carbonic acid gas* howsoever generated: and in our *public assemblies* carbonic acid gas, elevated temperature, and an atmosphere surcharged with aqueous vapour, and the exhalations of the skin, and pulmonary mucous surface.

1154. In any and every case the ample and free admission of fresh air and the complete and ready escape of the contaminated atmosphere are all that can be desired or attained. If we err, better that we err with too much than with too little

1151. Liebig's Familiar Letters, p. 340.

1152. Ibid. p. 339.

pure air. Air is not less the food of man than the "daily bread" on which he feeds. An impure or vitiated state of the atmosphere of his dwelling is infinitely more injurious to the general health and vigour of body than would be the most unwholesome and corrupt foods and drinks.

1155. A small amount of food will suffice the wants of man, but he imperatively requires a large and uninterrupted measure of the pure breath of heaven.

1156. It were not possible to find a stronger or more striking corroboration of the truth of this principle than is to be met with in the awful results of the atrocious immurement in the Black Hole in Calcutta, 21st June, 1756, of one hundred and forty-six human beings, a vast majority of whom were Europeans, by the Soubahdar of the provinces of Bengal, Behar, and Orissa, Mirza Mahmood, better known by his assumed name of Sooraj-oo-Dowlah. The narrative* states that

"It was about eight o'clock when these unhappy persons, exhausted by continued action and fatigue," (and several suffering from the effects of recent wounds,†) "were crammed together into a dungeon about eighteen feet square," (eighteen feet by fourteen,‡) "in a close sultry night," (in the sultriest season of the year,§) "in Bengal; shut up to the east and south, the only quarters whence the air could reach them, by dead walls, and by a wall and door to the north; open only to the west by two" (small ||) "windows strongly barred with iron, from which they could receive scarce any circulation of fresh air" (an evil aggravated by the overhanging of a low verandah¶).

* Mr. John Zephaniah Holwell, India Tracts, p. 392.

† History of the British Empire in India, by Edward Thornton. London, vol. i. p. 193.

‡ Cooke's Evidence in First Report of the Select Committee of the House of Commons.

§ Thornton, op. cit. vol. i. p. 193.

|| Ibid.

¶ Ibid.

"They had been but a few minutes confined before every one fell into a perspiration so profuse that no idea can be formed of it. This brought on a raging thirst, which increased in proportion as the body was drained of its moisture. Various expedients were thought of to give more room and air. Every man was stripped and every hat put in motion. They several times sat down on their hams, but at each time several of the poor creatures fell and were instantly suffocated or trodden to death.

"Before nine o'clock every man's thirst grew intolerable and respiration difficult. Efforts were again made to force the door, but still in vain. Many insults were used to provoke the guards to fire upon the prisoners, who grew outrageous, and many of them delirious. 'Water, water!' became the general cry. Some water was brought; but these supplies, like sprinkling water on fire, only served to raise and feed the flames. The confusion became general and horrid, from the cries and ravings for water, and some were trampled to death. This scene of misery proved entertainment to the brutal wretches without, who supplied them with water that they might have the satisfaction of seeing them fight for it, as they phrased it; and held up lights to the bars, that they might lose no part of the inhuman diversion.

"Before eleven o'clock most of the gentlemen were dead, and one-third of the whole. Thirst grew intolerable; but Mr. Holwell kept his mouth moist by sucking the perspiration out of his shirt-sleeves, and catching the drops as they fell like heavy rain from his head and face. By half an hour after eleven most of the living were in an outrageous delirium. They found that water heightened their uneasiness, and 'Air, air!' was the general cry. Every insult that could be devised against the guard, all the opprobrious names that the viceroy and his officers could be loaded with, were repeated to provoke the guard to fire upon them. Every man had eager hopes of meeting the first shot. Then a general prayer to heaven to hasten the approach of the flames to the right and left of them

and put a period to their misery. Some expired on others; while a steam arose, as well from the living as the dead, which was very offensive.

"About two o'clock in the morning they crowded so much to the windows that many died standing, unable to fall by the throng and equal pressure around. When the day broke the stench arising from the dead bodies was insufferable.

"At that juncture the Soubahdar, who had received an account of the havoc death had made among them, sent one of his officers to inquire if the chief survived. Mr. Holwell was shewn to him,* and it was near six when an order came for their release.

"Thus they had remained in this infernal prison from eight at night until six in the morning, when the poor remains of one hundred and forty-six souls, being only twenty-three, came out alive, but most of them in a high putrid fever."†

"Of these several were soon after carried off by putrid diseases, the consequence of the cruelty to which they had been subjected."‡

Mr. Holwell was in a state of high fever, unable to speak until water was given him, or to walk or to support himself without assistance.§

1157. Such, then, are the frightful consequences of overcrowding and huddling together in a limited space, without free ventilation, a large number of human beings exposed to the poison of their own contaminations, carbonic acid gas, and the secretions from the skin and pulmonary mucous surfaces.

1158. Mr. Wakley, the coroner for West Middlesex, has stated, "that in his district alone, at least 150 children annually lose their lives from inhaling under the bed-clothes

* Mr. Holwell, who was a Member of Council, assumed the command of the fort at Calcutta, on the ignominious flight of the Governor, Mr. Drake, and of the Commandant, Captain Minchin.

† Mr. Cooke, another of the prisoners, stated in his Evidence before the Select Committee of the House of Commons, that "only twenty-two came out alive."

‡ Thornton, op. cit. vol. i. p. 195.

§ India Tracts, p. 405.

the *carbonic acid gas* exhaled from their lungs and skin during sleep, the blood becoming poisoned for want of pure air."

1159. It has been repeatedly observed that in mills and factories the workmen invariably exclude, to the utmost of their power, the external air, not so much from the nature of their occupation as from choice. If the overseer insist upon the ventilators being kept open, the operatives strike for increase of wages, on the ground that fresh air quickens their appetites and occasions a larger demand for food than their wages will admit of their procuring.

1160. On the same principle the half-starved Dunstable bonnet-makers huddle and pack themselves together into the smallest possible space in a close, unventilated room, without fire, during the winter months, endeavouring by the emanations from their own bodies to keep each other warm, and to cheat Nature herself of that sustenance for which she would otherwise cry aloud.

1161. Enough has been said to shew the fearful and incalculable deterioration of health, not to say loss of life, consequent upon insufficient water-supply, crowded apartments, close, confined, and unventilated rooms and dwellings, contaminated atmosphere, and exhalations from drains, sewers, and cesspools. It only remains to inculcate, in the strongest and most earnest manner, the necessity for an ample supply of the pure breath of heaven.

1162. If, then, we would enjoy the blessing of health, we must take especial care that there be a free and unrestricted circulation of pure air in and around the dwellings of the whole community, both of the rich and of the poor. There should be no alleys, no courts, no *culs-de-sac,* no high walls, no interruptions to the movements of the atmosphere.

1163. In fine, the true and natural mode of ventilation, whether in public or private buildings, in dwelling or sleeping rooms, in nurseries, sick chambers, or wards of hospitals, in stables or kennels, is to admit air as freely as light, to give it ingress and egress on all sides, and to allow it to take its own course.

CHAPTER VI.

CLIMATE.

1164. *Climate*, in its broadest and most extended signification, embraces the nature of the *soil*, and its *cultivation;* the *elevation* and *position* of a country or certain locality; the general state of the *atmosphere*, its purity or contamination; the degree of habitual *transparency* and *serenity* of the *sky*, in connection with the amount of radiation from the ground; the *temperature*, *humidity*, *prevailing winds*, *calms*, and *storms*, *barometric pressure*, and *electric tension*.

1165. The meteorological phenomena on which the nature of climate depends are more especially connected with the relations of *air* and *moisture*.

1166. *Heat* and *moisture* are unquestionably the two most important agents which nature employs in producing those various modifications and incessant changes which take place in the lower regions of the atmosphere.

1167. The most poisonous gases, mephitic emanations, malarious, miasmatic, and paludal exhalations, the product of putrefactive changes of *organic* and *vegetable* origin, are extricated by the *former*, and dissolved and retained in the atmosphere by the *latter*.

1168. These emanations and gaseous products are, as we have already seen, the fruitful sources of all the most formidable and fatal scourges which have depopulated, in various ages, the localities in which they were developed, or the

1165. Leslie, op. cit. p. 37.

1166. Ibid. p. 90.

countries to which they were borne by the atmospheric currents.

1169. On the other hand, the equable and genial temperature, the purity, the clearness, the serenity, and tranquillity of the atmosphere exert a powerful influence upon the developement of the animal and vegetable kingdoms, the organic evolution of plants, and the ripening of fruits; and contribute, in no small degree, to the sustentation of health, and the prevention, amelioration, or arrest of disorder and disease.

1170. Can we then in the selection of our locale overrate the paramount necessity for a due attention to *aspect, soil, elevation, temperature*, and *humidity?* But if these considerations be important in health, how much more essential are they in disease.

1171. Is it of no importance whether the aspect of our dwelling be northern, eastern, southern, or western? whether our habitation be situate on the sea shore, the island, or in the interior of the country; in the city or rural village; on the mountain top or hill side; in the misty vale or open plain; by the tidal river bank, on the borders of the lake, or near the fenny moor? Is it of no moment whether it be sheltered from this wind or exposed to that? or whether certain winds be charged with local impurities and contaminations, or with pestiferous paludal or marsh emanations; whether the country around us be open and bare or close and wooded, in a high state of cultivation or neglected and waste? matters it not whether the air be dry, bleak, tonic, and bracing, or damp, foggy, soft, and relaxing; whether calms, storms, and gales be of frequent occurrence; whether much or little rain fall in the course of the year; whether the temperature of the locality be liable to constant vicissitudes, its mean daily range large or small, or its mean annual temperature that of Madeira, London, or Moscow; whether the soil be of limestone, gravel, sand, chalk, marl, or clay; the water pure, and free from calcareous salts (1233), and its supply ample; or whether the drainage

and sewerage be easy and perfect, or difficult, defective, or impossible?

1172. These and many other equally weighty considerations must and ought to obtrude themselves upon our attention in the selection of ground for encampments, sites for barracks, gaols, and union houses, hospitals, colleges, and other public buildings; but individually they embrace much that concerns each of us in the choice of our *dwelling*, whether with a view to the sustentation of fair average health and vigour of body, or to the improvement of an impaired or diseased frame.

Let us consider each of the preceding conditions separately; and first,

1173. *Aspect.*—The ancient physicians attached much importance to aspect. Hippocrates, in the chapter on "*Airs, waters, and places,*" says, "the inhabitants of towns situate between the summer settings and summer risings of the sun (NORTH) are exposed to cold winds, are well braced and slender; given to excess of eating but not of drinking, and are rather long lived. Pleurisies and acute diseases prevail epidemically, epistaxis in summer, and obstipatio generally. Menstruation is irregular, painful, and in small quantity.

1174. "The inhabitants of those towns which are exposed to winds between the summer and winter risings of the sun (EAST) are likely to be more healthy than those of towns which are turned to the north. The heat and cold are more moderate, and the sun in rising dispels the morning vapours. The inhabitants are well coloured and blooming, and have clear voices. The climate of such towns resembles *spring* as to moderation between heat and cold. The diseases are few in number, feeble in character, and bear a resemblance to those which prevail in regions exposed to hot winds.

1175. "The inhabitants of towns exposed to hot winds, between the wintry rising and the wintry setting of the sun (SOUTH), neither eat nor drink much. The women are sickly,

1173. Sec. iv. 1174. Sec. v.

subject to excessive menorrhagia, abort frequently, or are barren. The men are subject to dysentery, diarrhœa, and intermittent fever; in winter to fevers, cutaneuos eruptions, and hæmorrhoids. They are not liable to acute diseases, to pleurisies, peripneumonies, or ardent fevers, for such diseases do not prevail where the bowels are loose.

1176. "Towns facing the WEST resemble autumn in the changes of the day, inasmuch as the difference between morning and evening is great. The sun does not dissipate the morning mists, and in the latter part of the day the setting sun is scorching. In summer cold breezes blow from the east, and dews fall. The voices of the inhabitants are rough and hoarse, owing to the state of the air, which is generally impure and unwholesome, in consequence of the want of north winds to purify it. The winds and evening breezes are of a very humid character. The situation of such towns must necessarily be very unhealthy."

1177. There cannot for a moment be a question on the subject of aspect. In our island, a residence exposed to the north or east will of necessity be colder than one enjoying a southern or western aspect. The first will never be illumined or warmed by the direct rays of the sun, whilst the south will revel in the enjoyment, even in this country, of a comparatively tropical clime. An eastern, though brighter than a northern aspect, is not so sunny or so agreeable as a southern or western situation. There is no doubt that a southern and a western aspect, especially if combined in the same residence, are those most conducive to health, and best suited to sufferers from disease. These advantages of position will be immensely increased if the locality be protected from the north or east, or from both, by a chain of hills, or by umbrageous forests. A northern or eastern is less genial to rheumatism and pulmonary affections than a southern or western aspect.

1175. Sec. iii. 1176. Sec. vi.

1178. *Islands and the Sea Coasts of Continents.*—"The *ocean* follows with extreme slowness the alterations in the temperature of the air, and in virtue of this property, acts as an equaliser of temperature. It moderates the rudeness of the winter's cold, and the fervour of the summer's heat, and hence the difference between the insular or sea-board climate, which all deeply indented continents abounding in bays and promontories enjoy, and the climates of the interior of great masses of terra firma."

1179. The nearer is a place to the sea the less will be the extremes of heat and cold.

1180. The atmosphere of *islands* and of the *sea coasts of continents* is more *invigorating* and more *salubrious* than that of the interior of continents and inland places, in consequence of the large amount of *ozone* diffused through it. In temperate latitudes it is *warmer* than that of the interior of continents, and inland places in the same degree of latitude, in consequence of being subject to a cloudy sky, on which account it loses a smaller quantity of heat, at night, through radiation; and for this reason, also, the atmosphere of islands and of the sea shore is *warmer* in *winter*, and *cooler* in *summer*, than that of continents and places in the same latitudes far distant from the ocean; and, hence, is of a more equable temperature throughout the entire year.

1181. In the *torrid zones*, however, the temperature of the atmosphere of islands is *below* that of continents, in consequence of the cooling influence of the waters of the ocean gradually exercised on the winds during their passage over it.

1182. The atmosphere of the *east* coasts of continents, in both hemispheres, unless influenced by oceanic currents running near the shore, is drier, colder, and more bleak than that of the *west* coasts, which is moister, warmer, and milder.

1183. The *temperature* of the *west* coasts of *North America*,

1178. Kosmos, vol. i. p. 352.
1180. Wells, op. cit.
1182, 1183. Kosmos, vol. i. p. 351.

in the middle latitudes, corresponds with that of the *west of Europe* within the same parallels.

1184. It need scarcely be remarked that the *temperature* of the more *northern* latitudes is colder and less genial than that of the *southern* latitudes.

1185. Of this island, the atmosphere of all places lying to the *westward* of the meridian of Greenwich, becomes, in the ratio of distance, milder, warmer, softer, and moister. At the Land's End, the warm vapours of the Atlantic are brought up so constantly and so bountifully by the upper or returning trade winds, that it rains almost daily, the vapours being chilled in the colder regions of our latitudes. Here vegetation luxuriates; the myrtle and the rose live, flourish, and flower in the open air, the year through; and winter is robbed of much of its severity, whilst on the *eastern* coasts, in consequence of the dryness and lower temperature of the easterly winds, it is felt in all its intensity and bitterness.

1186. The *rain-fall* on the *western* coasts of England ranges from 30 to 51 inches; and on the *south-eastern*, the "*rainy*" point of our island, (558,) from 16 to 24 inches only.

1187. As instances of the superior and very moderate mean temperature of the air of *islands* in low latitudes, we may adduce that of the Isles of Wight, Jersey, and Madeira, contrasted with that of the Environs of London.

	Mean Annual Temperature.	Mean Winter Temperature.	Mean Summer Temperature.	Difference of Mean Temp. of Winter and Summer.	Difference of Mean Temp. of Warmest and Coldest Months, or Mean Annual Range of Temperature.	Mean Daily Range.	Mean Daily Variation.
Environs of London	48·81°	42·0°	65·6°	23·60°	28·24°	15·0°	4·03°
Undercliff, Isle of Wight . . .	51·11°	42·14°	60·28°	18·14°	20·47°	10·0°	3·75°
Jersey	53·06°	43·82°	62·84°	19·02°	22·14°		
Madeira . . .	64·56°	59·50°	69·33°	9·83°	14·50°	10·0°	1·11°

1188. *Towns and Cities.*—The atmosphere of all large towns and cities is loaded with the products of combustion, carbonic acid gas, sulphurous and sulphuric acids, sulphate of ammonia, carbonaceous matter, sulphuretted, free, and carburetted hydrogen; contaminated with the impurities, leakage, and imperfect combustion of coal gas; poisoned with the exhalations from the refuse and excrementitial matters from shipping and craft in the docks and navigable rivers, and from the offal, garbage, and putrefying animals cast on their banks, and with the morbific emanations from the waters themselves, saturated and reeking with the filth and blood from slaughter-houses, the excrement of animals, and the sewage of the city itself.

1189. These impurities become condensed and entangled in the mist and vapour of the atmosphere, and in the smoke of the city, over which, during the absence of aerial currents, they hover as a cloud, not merely obscuring the atmosphere, but infecting the inhabitants.

1190. Dr. Macculloch has however suggested that, as malaria "is experimentally decomposed by fire and smoke, it is probable that, amid the unknown mixture which forms the atmosphere of crowded cities, it is actually destroyed." (954.)

1191. Plants are exceedingly sensitive to an atmosphere surcharged with impurities, and suffer and fade and pine away in that of a city loaded with carbonaceous and gaseous matters.

1192. The temperature of the atmosphere of cities is superior London to, and the mean daily range infinitely less than, that of the country, the thick atmosphere by day offering a screen to the full influence of light and heat, whilst the temperature of the air by night must be raised by contact with the waters of the rivers flowing through it, which it has been shown are from circumstances greatly in excess of that of the minimum temperature of the atmosphere.

1193. Cities and towns built on emanating ground have

1192. Glaisher, Meteor. of London, p. 41.

been rendered comparatively healthy by flagging and paving the streets, whereby the malarious exhalations have been repressed or kept down.

1194. The mortality of cities is greatly in excess of that of the country. In the city of London the annual death-rate is 25 in every 1,000, or 1 in every 40 of the inhabitants; but in some of the more dirty and least ventilated parts it amounts to 27 in every 1,000, or 1 in every 37.

1195. According to the Registrar-General's report for the quarter ending 30th December, 1857, "the mortality in the towns appears to be at the rate of 2·704 per cent. = 27·74 per 1,000; in the country at the rate of 1·926 per cent. = 19·26 per thousand per annum."

1196. The annual standard mortality throughout England and Wales of men, women, and children, placed under the most favourable circumstances of open country thinly-populated, agricultural pursuits, pure air, uncontaminated water, and the absence of the poison of gin palaces, crowded assemblies, &c. has been found by experience, year after year, not to exceed 17 per 1,000.

1197. The excess, therefore, over the "standard mortality" amounts in towns to 10·74, and in the country to 2·26 in every thousand of the inhabitants.

1198. "Is this excess inevitable?" asks the Registrar-General. "This," he replies, "cannot be admitted for a moment, if we regard only the imperfect state of those sanitary arrangements which the public authorities of London have within their power; neither can it be admitted that the excess of five deaths, or 22 deaths instead of 17, a-year, in every 1,000 living is inevitable in England and Wales, with evidence before our eyes of the same violations of the laws of nature in every district."

1199. "The excess of deaths in England and Wales in 1857, that is, from causes which were for the most part, if not altogether, remediable, was 91,856. Of these unnatural deaths

18,328 happened in the country or in the village districts, and 73,528 in the town districts."

1200. "Of the 28,000,000 people who dwell within the shores of these islands, 140,000 die every year unnatural deaths; 280,000 are constantly suffering from actual diseases, which do not prevail in healthy places. The annual number of deaths in the United Kingdom is about 616,000, and the number constantly sick is about twice the number of the annual deaths, or 1,232,000. If the annual rate of mortality per 1,000 were reduced from 22 to 17, the deaths would fall to 476,000, the constantly sick to 952,000."

Too true is it, that "in the matter of health we are all very ignorant or desperately negligent."

1201. Between 20 and 35 years the average annual rate of mortality for the *whole country* is 9 in every 1,000; in purely country parishes 7 per 1,000; but in large towns and cities it is as high as 12 for every 1,000.

1202. London during the sixteenth century was in a most disgusting and filthy state. In the streets, which were extremely narrow and ill-paved, heaps of the most noisome filth were allowed to accumulate at assigned spots called lay-stalls; the sewers were very imperfect and badly constructed; the buildings were overcrowded, and the inhabitants dirty and uncleanly in their habits. The population lived about twenty years, and 50 died annually out of every 1,000. With a great increase of number the population now lives about 37 years, and the mortality has fallen to 25 in 1,000.

1203. At Paris and other capitals of continental Europe the annual rate of mortality is from 30 to 40 per 1,000.

1204. *Villages*.—The atmosphere of the rural village, per-

1202. Sir Gilbert Blane, Med. Chir. Trans. vol. iii. pp. 102, 103.
Vide Erasmus' Epistles; Hentzner's Travels in England in the time of Queen Elizabeth; Davila's History of the Civil Wars of France, book iii. Davenant, London, 1673, p. 351; and Registrar-General's Report for the Quarter ending 30 Dec. 1857.

fumed with the sweets of many a flower, is pure, uncontaminated by carbonic acid gas, smoke, the products of combustion, and the noxious vapours from the waters of empoisoned rivers and reeking sewage. If it be occasionally deteriorated by malaria or marsh miasm, these are diluted or dispersed by the winds of heaven, are rendered comparatively innoxious by the excess of oxygen exhaled by the luxuriant vegetation in the decomposition of carbonic acid gas, or are absolutely destroyed by the almost constant presence of ozone.

1205. *Mountains, hills, and elevated situations.* These exercise considerable influence over climate, by the direction in which they lie with respect to the sun's course, and by their height and the winds which they arrest, or to which they give passage.

1206. Countries lying to windward or westward of extensive mountain chains, are warmer than those to leeward or to the eastward.

1207. The atmosphere of elevated localities is colder, thinner, more transparent, drier, purer, more bracing, more elastic, more exhilarating, and more ozoniferous than that of the vale or plain below.

1208. As a rule, malaria is rarely met with on hills and elevated situations, unless generated by stagnant pools on the table-land or plateaus of the hills themselves, its great specific gravity precluding its ascent to high grounds.

1209. Elevated localities are exempt from typhus and remittent fevers, and are in every respect more healthy than the valley or plain.

1210. Most of the ancient towns and cities were situated on hills.

1211. The atmosphere of mountains and high situations, says Aristotle, is much more agitated than that of low ground.

1212. More rain falls among the mountains than in the plain.

1211. Meteorol. lib. i. c. x.

1213. The reading of the barometer is not so high on hills and mountains as in the plains below. This arises from two causes—elevation, and the absence of malaria.

1214. Mountain travelling, in consequence of the purity, elasticity, and ozoniferous qualities of the air, is highly conducive to health.

1215. The effect on the pulse and respiration, of mountain travelling, and of the attenuated air of elevated localities, has been already discussed. (763, *et seq.*)

1216. From numerous experiments made by M. de Saussure, with the eudiometer, on the atmosphere of the summit of the Buet, of the Great St. Bernard, of the Piton, and of the Voirons, he arrived at the conclusion that the air of these elevated localities is less pure than that of the plains and valleys at their feet. "We may conclude," says he, "that, in general, the atmosphere at a certain height loses something of its purity." "And it would appear that if the air of low plains be less salubrious, because it is loaded with heavy exhalations which it sustains by its density, that, on the other hand, that of mountains more than 500 or 600 toises (3,196·85 or 3,836·22 feet) above the sea-level is vitiated by other exhalations, which, possibly lighter than common air, do not the less impair its salubrity. In short, there is a certain medium height in which the density of the air is, all other things being equal, best suited to the life and health of man." That height he considers to be that of the plains and valleys of Switzerland, situate from between 200 to 300 toises (1,278·74 to 1,918·11 feet) above the sea-level.

1217. Dr. Lombard, in a paper on "*Mountain Climates considered in a medical point of view*," has endeavoured to shew that mountain air is as injurious in certain cases as beneficial in others, and that, in selecting a mountain climate for an invalid, due regard must be had to the nature and requirements of the case. He classifies mountain climates under three distinct heads:—

1216. Op. cit. tom. i. pp. 431, 432.

1st. The tonic and *soothing*, *below* 1,000 metres (=3,280·855 feet) of elevation above the low valleys or mid-regions of the Alps, such as Mornex, St. Gervais, and places overlooking the lakes of Thun, Brienz, and Lucerne.

2ndly. The tonic and *invigorating*, *about* 1,000 metres above these valleys or mid-regions, such as Monnetier, Treize Arbres on the Salève, Voirons, and Lalliaz.

3rdly. The tonic and *exciting*, *above* 1,000 metres above these valleys or mid-regions, such as Comballaz, Grion, Gurnigel, Rosenlaui, and the Righi.

1218. Dr. Lombard states that phthisis pulmonalis is seen but rarely beyond a height of 1,000 metres *above* the low valleys or mid-regions of the Alps, and that, at 1,500 metres (=4,921·282 feet) above these, it entirely disappears; and, further, that *asthma* is peculiar to the *highest elevations*.

1219. As the frequency of the pulse and of the respiration is in the direct ratio of elevation, (774 *et seq.*,) it were not only interesting but instructive to inquire the extent to which both would be accelerated by, and also to ascertain the temperature of, that attenuated and colder atmosphere which checks or arrests the developement of phthisis.

1220. The Lake of—

Lucerne,	47° 3′	N.L. is	1,320	feet above	the sea-level.
Zug,	47° 5′	,,	1,770	,,	,,
Thun,	46° 45′	,,	1,780	,,	,,
	3)140° 53′		3)4,870		
	46° 57′		1,623 ft.		

1221. If we, therefore, assume the average height of the low valleys or mid-regions of the Alps, in which phthisis pulmonalis is "very frequent," to be 500 metres = 1,640·427 feet above the sea-level, and if to this we add 3,280 feet = 4,920 feet, we shall have the height of that region in which phthisis is "exceedingly rare:" an addition of 1,640 more feet

= 6,560 feet, will give us that region in which phthisis "entirely disappears." (1218).

1222. Adopting M. Parrot's calculation, the *action of the heart* at 4,920 feet would be accelerated 12 beats, the *respiration* three additional inspirations; and, at 6,560 feet of elevation, the heart 20 beats, and the respiration five inspirations, per minute. (778).

1223. The *temperature* would be diminished at the lower by 16·4°, and at the higher elevation by 21·86° Fah. (90).

1224. Assuming also the average latitude of these low valleys or mid-regions to be 46° 57′, their mean annual temperature will be 55·834° Fah. If from this, 16·4° be deducted, it will give 39·434° for the mean annual temperature of the *lower* elevation; and if 21·86° be subtracted from 55·834°, it will leave 33·974° as the mean annual temperature of the *upper* altitude.

1225. It would therefore appear that phthisis is controlled, arrested, and prevented by an amount of *cold* almost approaching to freezing point, even though this be associated with an attenuated and ozoniferous atmosphere, productive, as a necessary consequence, of acceleration both of respiration and circulation.

1226. This fact is confirmed by the observations and researches of physicians resident in the colder northern latitudes. (1333).

1227. The Prior of the Hospice of the Great St. Bernard, in answer to certain questions put to him in reference to the effect of the climate of the hospice on the religieux, replies, that "the diseases to which the monks are liable are inflammations of the chest. The greater number of them become *asthmatic* after a certain number of years and are obliged to go down again to the plain. (784, 785.) Those who have been born among the mountains can reside for a long time with impunity at the convent."

1228. It has been hinted at by Sir John Forbes that "ordinary bronchocele, the aggravated bronchocele or goitre of the

larger Swiss valleys, and also cretinism," are the product of "some form of that unknown local influence or thing commonly recognised under the name of *miasma* or *malaria*."

1229. M. de Saussure is of opinion that cretinism is not the effect of malaria.—"On voit des villages cruellement affligées par le crétinisme, sans qu'il existe aucun marais dans leur voisinage, Villeneuve d'Aoste est un example frappant de cette verité." At the same time he admits "the possibility, nay, the probability, that the exhalations from marshes situate at the bottom of some of the valleys in which cretins abound may contribute to the production of the disease." M. de Saussure "believes cretinism to be occasioned by the excessive heat of the solar rays, and consequent stagnation and corruption of the air pent up by the mountains which encircle the deep and close valleys."

1230. Cretinism and goitres abound in valleys "médiocrement elevées," and are neither seen in the higher valleys nor met with in open and exposed plains.

1231. The inhabitants of wide valleys on the side exposed to the direct influence of the sun's rays, and to the reflected heat of the rocks above, are more subject to the disease than are those of the villages opposed to the north. The village of Branson, situated at the foot of a rock, exposed to the full south, and consequently liable to a very elevated temperature, abounds with cretins.

1232. Endemic goitre or bronchocele has been commonly attributed to the use of *snow-water* for drinking and culinary purposes; but the disease is met with where snow is never seen (Sumatra), and is not always met with where snow-water is invariably drank.

1228. A Physician's Holiday; or, a Month in Switzerland in the Summer of 1848. London, 1850, pp. 187, 188. Macculloch, op. cit.

1229. Op. cit. tom. ii. pp. 412, 413, § 1035.

1230. Ibid. p. 410, § 1033.

1231. Ibid. p. 412, § 1035.

1233. The researches, experience, and observation of Messrs. Coindet, Richardson, Manson, M'Clelland, Bally, Inglis, and others, lead to the conclusion that the endemic disease depends on the presence in the *water* used for culinary and drinking purposes of calcareous salts, the carbonate or sulphate of lime, derived from its contact with limestone rocks, and not upon malaria or the stagnant atmosphere of close, pent-up valleys.

1234. Mr. M'Clelland affirms that it is possible to predict *à priori*, by examination of the rocks of any given locality, whether the inhabitants are affected with goitre, and that in a survey of 1,000 square miles no instance occurred in which goitre prevailed endemically where the villages were not situate on or close to limestone rocks.

1235. The inhabitants of mountainous countries are, for the most part, healthy, hardy, and capable of enduring great privations and fatigue, and hence they make the best soldiers, *e. g.*, the Highlander and the Swiss.

> "Turn we to survey
> Where rougher climes a nobler race display;
> Where the bleak Swiss their stormy mansion tread,
> And force a churlish soil for scanty bread;
> No product here the barren hills afford,
> But man and steel, the soldier and his sword."

1236. *Valleys and low-lying lands.*—The atmosphere of these localities is surcharged with moisture, possibly with malaria. Little or no ozone is found in the atmosphere of valleys and low-lying lands, because as a rule it has been consumed or destroyed in decomposing miasmata. This was particularly noticed in the atmosphere of the valley of the Thames during the last visitation of the pestilential cholera. Mists and fogs, holding miasmata in solution, abound in valleys. Grass meadows, as a rule, are unhealthy, and emit malaria.

1237. The atmosphere of valleys is chilly before the sun's rays dissipate the morning mists. During the forenoon, mid-

day, and afternoon, the temperature has attained its maximum, and is succeeded by the cold mists and fogs of evening. Mountain chains influence the temperature of valleys to a very considerable extent. Valleys and plains on the north side of lofty mountains, being deprived of the warming and cheering rays of the sun, are cold and gloomy, and their vegetation is retarded in a proportionate degree.

1238. Typhus fever is more prevalent in low than in elevated situations.

1239. *Open plains* are liable to winds from all quarters of the compass. *Sandy plains* are malarious.

1240. *Rivers.*—The banks of rivers and adjacent lands are subject to haze, mists, and fogs, the consequence of exhalations and evaporation from the surface of the water (1054). The greater the difference between the temperature of the water and that of the atmosphere, the more dense will be the mist or fog.

1241. In hot climates the banks of rivers are highly pestiferous.

1242. The borders of running streams slowly meandering through low grounds are malarious, unless they be under grain cultivation.

1243. The banks of tidal rivers, surcharged with the sewage, offal, and refuse animal and vegetable matter of towns in a state of decomposition, exposed twice during every twenty-four hours by the ocean-tide to the influence of the atmosphere and the heat of the solar rays, are productive of poisonous and mephitic emanations, which engender fever, diarrhœa, and cholera. (945, 1053.)

1244. When the temperature of the waters of rivers exceeds 60° Fah. the minimum temperature of the atmosphere being below this, diarrhœa will prevail, and will not subside until the temperature of the water declines below 60°. (985, 1060.)

1245. *Lakes and lagoons.*—When these retain a considerable depth of water, and when their banks are steep, no malaria is

given off; but if any sensible diminution of the waters occur, or if these retire from their shores, exposing to the solar influence animal and vegetable remains in a state of decomposition and decay, malaria is extricated, and intermittent or remittent fevers are the consequence.

1246. The alluvial tracts at the entrance and exit of the lakes of Switzerland and other countries are sources of malaria.

1247. We read in Pliny that "the putrid lake, Sibaché, or Sivaché Moré, is a vast lagoon, covered with water, when an east wind blows, by the waters of the sea of Azof, but at other times is a tract of slime and mud, sending forth pestilential vapours."

1248. *Fens and moors.*—These exhale malaria to a fearful extent, and, unless there be ample vegetation in their immediate vicinity or on their own surface to decompose it, the miasma is conveyed by the winds to the dwellings and villages in their neighbourhood, among the inhabitants of which it produces intermittent, remittent, or typhus fevers. Of this we have abundant evidence in the fens of Lincolnshire and the marshes of Essex.

1249. *Swampy forests, swamps, if covered with vegetation,* and *peat bogs,* do not produce fever, in consequence of the malarious emanations being absorbed by the leaves of the trees, or decomposed and destroyed by the oxygen exhaled by the foliage, by the vegetation, and by the moss, *sphagnum palustre,* with which their surfaces are covered, first converted into ozone, or by both combined.

1250. Peat bogs, from the astringency of their water, are inimical to reptile life. Human bodies have been found in these bogs, tanned and preserved from decay by the astringent principle, consequent upon the decomposition, under water, of vegetable fibre.

1251. *Woods and Forests.*—As the atmosphere is not warmed

1247. Hist. Nat. book iv. cap. xxvi. note.

by the sun's rays in their passage through it, but derives its heat by radiation from the earth's surface, it is self-evident that woods and forests, by excluding the solar rays from the earth, and sheltering the winter's snow from wind and sun, must materially intercept this operation of nature, and by throwing off large quantities of watery vapour from, and absorbing solar heat by, their leaves, must greatly increase the amount of radiating or cooling superficial surface, and that the combined results must be that *wooded countries* are *much colder* than those which are open and cultivated.

1252. "The forests which cover America, and hinder the sunbeams from heating the ground, are a great cause of the temperate climate in the equatorial parts."

1253. It has been often observed in America that lands which were healthy, when covered with wood, have become extremely unhealthy when cleared and cultivated.

1254. It has been already shown (650) that the leaves of plants and trees exhale oxygen, and absorb carbonic acid gas. It has also been suggested that the *excess* of oxygen so given off, not necessary for the true chemically proportional combination with nitrogen to form or to renew the impaired atmospheric air, becomes associated with the vapour of the atmosphere, and converted by electrical agencies into ozone, or allotropised oxygen (331), the use of which is to decompose or destroy the malaria given off from the earth's surface (1073). It has also been suggested that the leaves of plants absorb or decompose malaria. (986, et seq.) In either case it would appear that wooded countries, as a rule, if cold are healthy.

1255. There is however strong reason to believe that *close* and *wet woods* in this country abound with malaria. It has been before shown, on the authority of Dr. Macculloch, (964,) that "malaria is especially united with that transferable substance which forms the foggy stratum, or that the lowest portion

1252. History of America, by William Robertson, D.D. 11th edition, 1808, vol. ii. note iv. p. 11.

of the atmosphere in the act of depositing water is its vehicle and its residence."

1256. *Drainage and Cultivation.*—Nothing conduces to check the generation and propagation of malaria so much as a *high state of cultivation*, and a dense population.

1257. Drainage and agricultural improvements of lands have been invariably followed by a rapid and proportionate diminution in the number of cases of remittent and intermittent fevers, the products of malaria.

1258. The *breaking up*, however, for the first time of *pasture lands* is attended by the production of malaria and its diseases; and the partial or imperfect draining of a swamp may, by converting it into a wet and noxious meadow, bring it into precisely that state which is peculiarly favourable to the extrication of malaria (982). In low countries the drainage may be sufficient for agricultural purposes, but totally inadequate to the eradication of malaria. The insalubrity may be lessened, but not annihilated.

1259. *Meadows, pasture, and grass lands* produce malaria; but, if ploughed up for grain cultivation, cease to give out miasmata.

1260. *Parks* and *pleasure grounds* ornamented by water produce malaria.

1261. *Dryness, humidity,* and *temperature* of the atmosphere. —The dryness, humidity, and temperature of the atmosphere are intimately associated with and dependant on the point of the compass whence the wind blows, and are as closely connected with, and as influential in controlling the health, disorder, disease, and death of all animal and vegetable creation.

1262. The atmosphere of certain localities is peculiarly dry, tonic, bracing, and invigorating, or harsh, bitter, parching, and oppressive. Of the former is that of hills, elevated situations, and gravelly and chalky soils, and of all those places, *cæteris paribus*, lying to the eastward of the meridian of Greenwich.

1256. Macculloch, op. cit. vol. i. p. 374.

1263. Mountain air is thin, bright, and elastic.

1264. *Dryness* and *cold* are the chief characteristics of northerly and easterly winds (535, 542, 549).

1265. A *dry* atmosphere is not conducive to health. If it be attended with a low temperature it is productive of inflammatory affections of the respiratory apparatus; if with an elevated temperature, it induces fevers, diarrhœa, dysentery, and cholera (518). Almost any amount of *cold*, however, may be supported without any serious ill effect upon the health, if the atmosphere be but *dry* and the weather perfectly calm (532).

1266. *Moisture.*—On the other hand, moisture, if accompanied by a high temperature, is beneficial in its effects upon animal life. *Moist* and *warm* air is most congenial to a dry and irritable condition of the pulmonary mucous surfaces. If associated with a *low temperature* it is productive of a vast amount of varied illnesses, *inter alia*, of bronchitis, rheumatism, erysipelas, mumps, &c.

1267. An atmosphere, saturated or loaded with moisture, interferes with the cutaneous and pulmonary exhalations. The former secretion, instead of evaporating, and relieving the internal heat, pours out, and is condensed in dew drops on the surface, without diminishing the temperature of the body.

1268. The atmosphere of all places in our island lying to the westward of the meridian of Greenwich, soil and local peculiarities excepted, and that of valleys, and of clayey soils, is damp, soft, and relaxing.

1269. It is more than probable that a relation exists between the moisture and temperature of the atmosphere, and the mortality of any given locality or country. *Humidity and moderate elevation of temperature conduce to health; moisture*, combined with a *low temperature induces disorder;* a *dry atmosphere*, even though associated with an *elevated temperature*, is *highly pernicious.* (518 et seq.)

1270. In a particular district of Scotland the number of deaths, during the same three months of three successive years,

was, according to the report of the Registrar General of that country,

Year.	Deaths.	Rain in Inches.	Average Temperature.
1846	995	12·5	60·5°
1847	1567	4·0	59·0°
1848	951	9·5	55·5°

1271. Whilst the temperature of 1846 and 1847 was very nearly the same, the amount of *humidity* in the latter year was *two-thirds less*, and the *mortality* nearly *three-fifths* greater than in the former year. In 1848, although the temperature was considerably lower, and the amount of *humidity more than double* that of 1847, the *mortality* was little more than *three-fifths* of the previous year.

1272. Aqueous vapour has a great affinity for organic matter, and is the means both of preserving and diffusing it. The disagreeable smell arising from drains and accumulations of filth, previous to rain, is to be attributed to this cause. The germ of cholera, for a like reason, pursues and adheres to the course of rivers. In short, the atmosphere is the receptacle for all vapours and impurities arising from evaporation and exhalation. The moister is the atmosphere the more readily are these detected by the olfactory nerves. An infecting or poisonous influence may, however, exist without any smell by which its presence may be betrayed.

1273. Moisture and warmth characterise southerly and westerly winds (566, 574).

1274. The atmosphere of tropical climates is warmer, moister, and less dense, and consequently contains less oxygen than that of colder latitudes, hence the exhausting influence of the heat of the former.

1275. The effects of a humid atmosphere were well known to and thoroughly understood by the ancients. That most

accurate observer of human nature, Hippocrates, writes, "Of all men the Phasians have the roughest voices, from breathing an atmosphere which is not clear, but misty and humid."

1276. "The river Alece," says Strabo, "divides Rhegium from Locris, flowing through a deep ravine. The grasshoppers in the territory of the Locrians *sing*, but those on the other side are silent; and it is thought probable that this is caused by the region being woody, and their membranes being softened by dew do not produce sound; but those on the Locrian side being sunned, are dry and horny, so that the sound is easily produced in them." The humidity of the atmosphere of this country so relaxed the vocal organs of Grassini, the celebrated singer, that her voice sunk nearly an octave in pitch, and was changed from a soprano to a contralto. On her return to the drier and more genial clime of Italy, it resumed its former soprano character, and she lost the power of producing the lower range of notes.

1277. Practically then we are taught to avoid exposure to a *moist* atmosphere when combined with a *low temperature*, and to a *dry* atmosphere when associated with an *elevated temperature.*

1278. The temperature of the air depends on the inclination of the sun's rays to the surface of the earth, on the distribution of land and water, the vicinity of the sea, the elevation of the land, the state of the countries whence come the prevailing winds, whether these pass over continents or extensive tracts of ocean, and upon various other circumstances. The mean annual temperature of places remains however nearly constant.

1279. The *heat* of climate depends not only upon the immediate effects of the sun's rays, but on their continued operation. This is the reason why the day is warmest about two o'clock in the afternoon, and coldest just before sun-rise; the

1275. *Περὶ ἀέρων, ὑδάτων, καὶ τόπων*, sec. xv.

1276. Lib. vi. c. i. sec. ix.

1278. Penny Magazine, article Isotherm.

1279. Robertson's America, vol. ii. note iv. p. 11.

summer warmest about the middle of July, and the winter coldest about the middle of January.

1280. *Continental climates* are characterized by Buffon as *excessive.* In the interior of the Asiatic continent the temperature of the summer months, for weeks together, is 86° and 87·8° Fah. The summer is followed by winter, in which the coldest month reaches the fearful mean temperature of from 0·4° to — 4° Fah.

1281. These variations of temperature depend on two causes, the direct influence of the solar rays, and the radiation of heat from the surface of the soil into the air resting upon it.

1282. Soil will absorb and retain more heat than water, especially than running water.

1283. To the great ocean which surrounds us we are indebted for the immunity from these extremes which we happily enjoy. In winter, the currents which blow over our island are warmed, and in summer cooled, by its nearly uniform temperature, and are at all seasons supplied with that amount of moisture so imperatively essential to health. (1180.)

1284. Some of the causes tending to *elevate* temperature. "The vicinity of western coasts in the temperate zone: continents cut up into numerous peninsulas; deep bays and far-penetrating arms of the sea; the prevalence of southerly and westerly winds on the western confines of a continent in the northern temperate zone; mountain chains which serve as screens against winds from colder countries; absence of forests on a dry sandy soil; the neighbourhood of a pelagic stream of running water of a higher temperature than that of the surrounding sea."

1285. A change has been said to have recently taken place in the direction of the Atlantic currents, by which the gulf-stream, which flows from the tropics and conveys a large amount of warmth to the northern parts of Europe, will be

1280. Kosmos, vol. i. p. 352.
1284. Ibid. pp. 348, 349.

borne more directly upon its western shores, whereby its winters, but more especially those of this country, will enjoy a much higher temperature than formerly.

1286. Some of the causes tending to *depress* the mean annual temperature by exciting cold. "Elevation above the level of the sea; the vicinity of an eastern coast in high and middle latitudes; unbroken outline of a continent without deep sea bays; mountain chains whose form and direction prevent the access of warmer winds; extensive forests which hinder the sun's rays from reaching the ground, and whose leaves" absorb the sun's rays, and "throw off large quantities of watery vapour, and thus vastly increase the amount of radiating or cooling superficial surface; a misty or overcast summer sky, and a very clear winter's sky."

1287. The rate of mortality bears a tolerably close relation to *temperature*. More deaths occur during a low than during an elevated temperature, and during the colder than during the warmer months of the year.

1288. The following table, shewing the mortality of Scotland for the years 1855 and 1856, fully bears out this statement:—

	1855.		1856.	
	Number of Deaths.	Temperature.	Number of Deaths.	Temperature.
January and February . .	13,194	31·5°	10,688	36·5°
March and April	11,804	40·0°	10,528	41·5°
May and June	9,989	49·5°	9,451	50·0°
July and August	8,941	58·5°	8,617	56·5°
September and October . .	8,435	48·0°	8,589	49·5°
November and December .	9,781	37·5°	10,583	38·5°

1286. Kosmos, vol. i. pp. 349, 350.

1289. *Night Air.*—In this country the unwholesome character of the night air is attributed to its coldness. Dr. Wells says, "to our loss of heat by radiation is probably to be attributed a great part of the hurtful effects of the night air." Descartes is of opinion that these are not owing to dew, but to the descent of certain noxious vapours, which, having been exhaled from the earth during the heat of the day, are afterwards condensed by the cold of the night. For this reason the practice of sleeping with open windows is highly dangerous, but more especially is this the case in malarious districts.

1290. It is generally admitted that in all countries the air is coldest about sunrise.

1291. *Morning and evening mists formed on low ground* are pernicious in their nature, from their holding miasmata in solution. When the former are dissipated by the morning sun, the latter are checked in their progress, possibly in their production.

"No one," says Dr. Macculloch, "fears a summer evening, or even a mild summer night, unless indeed he find a dew; yet here lies the very danger. A land of meadows, and parks, and ponds, and rivers, and woods is a thousand times more hazardous than all the nights of all the winters that ever were. This is the real night air to be feared, even tho' the grey mist should not rise, or the dew should not fall. To take a pleasant evening walk by the banks of the river or the lake, to watch the trout rise at the evening flies, to attend the milking of the cows in the green meadow, to saunter among wet groves until the moon rises, listening to the nightingale, these, and more of such rural amusements and delights, are the true night air, the malaria, and the fever."

1292. *Soil.*—"*A gravelly soil*," says Dr. Macculloch, "is healthy, because its easy drainage prevents the growth of that particular vegetation which is the cause of malaria."

1289. Op. cit. p. 251.
Meteorol. c. vi.

1293. Elevated gravelly sites are of necessity drier, and consequently more healthy, than low-lying gravelly soils.

1294. The gravel pits of commons, however, when filled with water, are a very general, and not less unsuspected, cause of ill-health.

1295. Dry and gravelly soils are exempt from typhus fever.

1296. *Clay.* "A clayey or marley soil is unhealthy, because, by permitting the accumulation and lodgement of superficial water, it generates, how partially soever, those marshy or undrained spots, or wet woods, or moist meadows, which are the sources of malaria, and, consequently, of the various diseases confounded under the vague term unhealthiness."

1297. *Stone* and *sand* have little capacity for caloric: they heat or cool, therefore, very rapidly, and to a great degree, and as readily, absorb or permit the percolation of water, which is again extricated by the solar rays in all the intensity and virulence of poisonous miasmata.

1298. The pestiferous nature of stone, limestone, and of sandy plains has been painfully illustrated (1000 to 1007) in the fearful loss which the British army sustained in the Peninsular campaign, and in the Walcheren expedition, when encamped on those soils.

1299. *Chalk.* If the chalk formation prove a very poor and barren soil, of itself, it is, next to gravel, the most healthy of all soils. It very rapidly absorbs water, and as sparingly returns it to the atmosphere.

1300. The air of chalky soils is dry, tonic, and bracing.

1296. Op. cit. vol. i. p. 21.

CHAPTER VII.

CLIMATE AND DISEASE.

1301. In the preceding chapters we have considered the atmosphere, the seasons, temperature, rain, winds, pressure, respiration, circulation, infection, contagion, malaria, ventilation, and climate, and have, as amply as would appear necessary, discussed each subject in all its various bearings upon the sustentation of health, or production of disorder or disease. We have now only to enter upon the consideration of *climate* in the treatment, amelioration, arrest, or cure of functional derangement and organic disease.

1302. It must, however, be premised, that the conditions most favourable to *health* are an average degree of *temperature, humidity, pressure*, and *electric tension*, and that any departure from these conditions produces effects proportionate to the amount of such departure.

1303. If this be true in the matter of health, with how much greater force does it apply to disorder and disease.

1304. Invalids are exceedingly sensitive to changes of the weather. The fluctuations of temperature, humidity, and pressure affect their delicate organization in a manner and degree which few but themselves can estimate or comprehend, and which are only exceeded by the effect of the variations in the amount and kind of electricity in the atmosphere.

1305. Possibly it may be deemed not only not irrelevant to the subject under consideration, but even desirable, to refer, though briefly, to the climate of this country in particular, as well as to those causes on which climate more immediately depends, before proceeding to examine those of other countries

which have deservedly acquired celebrity as residences for invalids.

1306. The climate of this country, as a necessary consequence of the variable winds which blow in our latitudes, is *exceedingly changeable;* but, notwithstanding this variableness, the difference between the temperature of winter and summer is, according to Mr. Glaisher, only 20·60°, and to Mr. Howard, 22·9°. (483.) For thus escaping the extremes of heat and cold we are indebted to the surrounding ocean, from which our winds derive their temperature. (1178.) Temperature, it has been already shewn, does not depend solely or entirely on the direct influence of the solar rays. To this *small amount* of variableness of the climate of our country its inhabitants owe the more robust health which they enjoy, and the greater longevity to which they attain, in comparison with those of the interior of large continents, Russia, for example, in which the difference between the average temperature of winter and summer is as great as 70° or 80°.

1307. The effects of *temperature* on the general health have been already adverted to (497), and reference has been made to the periodical return of "cold years" and "warm years," in connection with the recurrence of epidemic disorders. (379, 378.) This periodical invasion of disease is not, however, peculiar to our island; Livy tells us that in 173 years, *i. e.*, from 287 to 460 A.C., nineteen distinct plagues occurred, none of them at longer intervals than *seventeen* years, and some continuing for two or three years together.

1308. The results of any departure from a due amount of *humidity* in the atmosphere have been already referred to. (518 to 525, 1269 to 1277.)

1309. A high state of the barometric column, as indicative of a *dense condition* of the atmosphere, is associated with epidemic disease. (634.) *Diminished pressure* is attended with increased cutaneous exhalation, and, if the fall be rapid, is accompanied with numerous sudden deaths. (640.)

1310. It has been stated, on the authority of Mr. Glaisher (255,) and of Mr. Hingeston, (257,) that epidemic or pestilential diseases are associated with an absence or deficiency, and their presence with an increase, in the amount of positive electricity. The latter gentleman believes it "all but incontestable, that what is called negative electricity goes with diseases called asthenic, while the positive belongs to such as are sthenic or inflammatory." And that "the former is coincident with mild and moist weather; the latter with the cold and frosty, or the hot and dry."

1311. "The kind of electricity is certainly connected with the amount of daylight. There is less light on those days on which the negative electricity prevails, than on the bright, when the electricity is, with few exceptions, positive." "The public health is seldom favourable when the sky is grey, the air moist," (the temperature low,) "the daylight diminished, and the electricity negative. On the contrary, it is good when the season is open, the clouds distributed in masses, the moisture condensed into showers, the electricity positive, and the solar rays abundant."

1312. The amount of the annual mean *electrical tension* of the air for each quarter, and the *electric force* of each wind, has been recorded under the different "seasons" and "winds." (390, 412, 433, 538, 598.)

1313. It is to be regretted that with regard to the climate of other countries we are not in possession of very many particulars which we require, in order to enable us to form a more accurate judgment of their suitableness, or the reverse, as a residence for invalids labouring under various forms of disorder and disease.

1314. Yet, notwithstanding our limited knowledge on these matters, it is generally admitted that the beneficial influence of

1310, 1311. British Medical Journal, Febr. 27th, 1858, the Meteorology of 1856 and 1857, by J. A. Hingeston, Esq. p. 163.

climate in the treatment of disorder or disease of the viscera, of the thoracic and abdominal cavities, is established upon too extended an experience to require or admit of any observation or discussion.

1315. There is no climate in the habitable world which is not open to some valid objection; yet in the choice of a residence with a view to the mitigation or arrest of disorder or disease, there is a governing principle to guide and direct us. The constitution of the patient and the nature of the malady itself must be carefully considered and determined before the locality to be selected be decided upon.

1316. As a general rule, shelter and protection for the invalid should be sought from the north-east wind, the mistral, and the gale. A sunny aspect should be chosen, and particular attention paid to temperature, dryness, or humidity both of atmosphere and soil, and especially care should be taken that there be a free circulation of pure air.

1317. There can be very little doubt that, in the majority of disorders, an *elevated* situation possesses many and important advantages over valleys, plains, and low-lands; *inter alia*, a purer, drier, colder, more bracing, and more ozoniferous air, a greater freedom from fogs and mists; and greater facilities for more perfect drainage.

1318. On the other hand, valleys and plains have their advantages. The former possess a moist, soft, relaxing air, and, possibly, afford shelter from the inclemency of the northerly or easterly blast. The latter are open to the "four winds of heaven," and revel in the enjoyment of fresh air, and all the advantages of full and perfect ventilation.

1319. The *asthmatic*, whose malady is bronchitic, cannot bear the stimulus of the life-giving ozone of the hills, though he thrive and enjoy life in the mist and damp of the vale below. The converse of this may also obtain with the subject of this peculiar disorder, in whom a relaxed or congested condition of the mucous membrane of the bronchi exists. He

cannot bear the warmth and moisture of a low position, but will breathe freely under the stimulus of ozone.

1320. The same remark applies to soil; one individual can breathe comfortably only on clay, whilst another can exist only on chalk or gravel.

1321. The subject of a *dry tickling cough* may find comfort and relief in the greater warmth and moisture of the low-lying, clayey, or marly land; and, on the other hand, may suffer aggravation of his malady by a residence in the colder, drier, and more ozoniferous atmosphere of an elevated locality, or the more bracing air of a gravelly or chalky soil. Again, the subject of a *moist or relaxed mucous membrane* would flee from a moist atmosphere and clayey soil, and would seek the dry mountain air, or the bracing atmosphere of a chalky soil. In other words, a dry and irritable condition of the mucous lining of the larynx, trachea, and bronchi, inducing a dry cough, or cough unaccompanied with expectoration, requires a moist, soft, air, and a clayey or marly soil; and, on the contrary, a moist bronchial membrane needs a dry, tonic, bracing, ozoniferous atmosphere, and a chalky or gravelly soil.

1322. The preceding remarks do not, however, hold good with respect to the mucous surface of the *stomach and bowels.*

1323. The sympathy which exists between the external skin and the mucous membrane of the alimentary canal is of so sensitive a character, that impressions made on the former are transferred, as it were, by electric influence, to the latter.

1324. Dry and cold winds, by constricting the vessels of the surface, check the insensible cutaneous perspiration, and occasion internal congestions, which, in certain delicate individuals, are followed by *diarrhœa*, or *dysentery*; whilst, in the same subject, a moist, soft, warm atmosphere, by inducing external perspiration, will occasion constipation.

1325. The effects of external impressions on the alimentary canal are attributed by writers to various causes: thus Galen says, "*moist* weather affects the bowels, and produces belly

fluxes; *dry* weather, on the contrary, affects the *renal* organs." Crampton and Forbes give, as causes of diarrhœa, "*cold and wet*" impregnated with putrid exhalations; "*warm* and *damp*," and "*alternations of temperature*," as *hot* days and *chilly* evenings.

1326. The invalid labouring under *inflammatory dyspepsia* would find relief from the soft, moist, and warm atmosphere of a low-lying locality; and, conversely, aggravation of his complaint from a dry atmosphere and elevated situation; whilst the subject of *atonic dyspepsia, obstipatio*, or *amenorrhœa*, would be benefited by the latter, and rendered incomparably worse by the former. In every case the demand for food would be lessened in consequence of the increased temperature, whereby the stomach, from diminished exertion, would speedily regain its normal condition.

1327. We are told by Professor Johnston, in his "*American Notes*," that "more than one half of the population of the United States is affected by diseases of the digestive organs," of whom 14 die out of every 1,000. The mortality under this head in Great Britain is 0·5 in every 1,000. This almost universality of dyspepsia in North America is supposed to depend upon the great extremes, both of *temperature* and *moisture*, to which the climate is liable. For five winter months the northern states are ice and snow bound, and in summer are exposed to a burning tropical heat. The east and south-east winds, loaded with the steaming vapours of the gulf-stream, saturate everything with a dripping moisture; whilst the north wind, having passed over the huge continent of land to the north-ward, is so absolutely dry that it parches in summer and blights in winter all animal and vegetable creation.

1328. In other words, "as the quantity of our food is regulated by the number of respirations, by the temperature of the

1325. Cyclopædia of Practical Medicine, article "Diarrhœa," vol. i. p. 556.

1328. Liebig, op. cit. pp. 22, 23.

air, and by the amount of heat given off to the surrounding medium," it results that the intense cold of the five winter months necessitates a larger consumption of food than can be assimilated with the south or south-east winds. "The temperature of these is too high to admit of active exercise, and consequent accelerated respiration, in order to apportion the waste to the amount of food taken," and, as in all probability, this is not diminished in the ratio of increased temperature, dyspepsia or disease must ensue.

1329. In functional derangements of internal organs, in congestion of the *brain, liver, spleen, and uterus;* in *menorrhagia,* and in *habitual abortion,* a soft, relaxing air, by exciting cutaneous perspiration, affords one of the most effectual means of relief. Strangers in Rome suffer from menorrhagia during the winter months, from the dry and cold atmosphere of the "everlasting city."

1330. In *rheumatism,* climate exercises a powerful influence. Would the subject of this disorder, if left entirely to his own intuitive guidance and devices, select a northern or eastern aspect; would he take up his abode on a clayey soil, in a cold, damp, misty vale; would he locate himself at Pau, where rheumatism springs up indigenous with every blade of grass on the surface of the soil; would he not rather seek a dry, gravelly, and elevated spot, with a southern or western aspect, protected or screened from the bitterness of the north and north-easterly winds; would he not set himself down at Nice, Naples, Rome, or Palermo, and luxuriate in an equable and genial atmosphere?

1331. It is, however, more especially in organic *affections of the chest, in threatening and incipient phthisis pulmonalis* that climate, if well chosen, offers so many important and substantial advantages. But, on the other hand, if the selection be ill judged, climate may aggravate the disease, may entail much of

1328. Liebig, op. cit. pp. 22, 23.

suffering and distress, or may even accelerate the march and termination of that which it was intended to alleviate or arrest.

1332. *Phthisis.* Phthisis is supposed to be controlled by *cold* (1218, 1225) and to be prevented by *warmth* and *marine atmosphere.*

1333. The Swedish physicians affirm that the disease becomes less common as we proceed northward, and that "there is such a thing as a preventing action of the polar regions." In Iceland the disease is stated by Dr. Schleisner to be "unknown," and in Finmark, in Danish Lapland, to be "never seen." These views entirely accord with those of Dr. Lombard given above (1218, 1225).

1334. In warm climates the "preventive action" varies with the longitude. In the torrid zones the maximum corresponds to the West India islands, and the minimum to Madras.

1335. Islands and sea coasts, possibly on account of the large amount of ozone with which their atmosphere is charged, and of their more equable temperature, enjoy a comparative amount of immunity from phthisis, which is somewhat remarkable. The American physicians entertain a contrary opinion, and one to which Sir James Clark inclines. In Jersey phthisis is said, by the same writer, "not to be frequent." "Laennec observed that the proportion of consumptive diseases on the southern coast of Britany was comparatively small."

1336. The mortality from phthisis is infinitely less in the navy than in the army. This, however, may arise from a twofold cause, the greater purity and the higher ozoniferous character of the atmosphere of the ocean compared with that of the land, especially of intertropical climates, and the more severe duties of the soldier contrasted with those of the sailor.

From the report of the Registrar-General for 1841, it would appear that the mortality of England and Wales, from all

1336. The Sanative Influence of Climate, by Sir James Clark, Bart. M.D., F.R.S. London. 3rd edition, 1841, pp. 186, 187.

causes, amounted to 338,979, of which 59,559 were from phthisis, = 1 in 5·69, or 17·57 per cent.: that of London, of the total mortality, 91,565, the deaths from phthisis were 14,562, = 1 in 6·28, or 15·9 per cent.: in Berlin, of the total number of deaths, 73,216, phthisis yielded 12,800, = 1 in 5·72, or 17·48 per cent.: and of Paris, of the total mortality, 85,339, the deaths from phthisis were 15,375, = 1 in 5·55, or 18·02 per cent.

1337. In the selection of a residence for the consumptive or pulmonary invalid, *temperature* is a primary and most important element; *moisture*, *aspect*, *soil*, and *elevation* are the next considerations.

1338. The temperature of the locality should be, night and day, as nearly equable as possible. The *day temperature* should be *low*, that of the *night*, *high*, and the *mean daily range small*.

1339. It has been shewn before, that, as a rule, the climate of islands and of the sea-coast approximates more nearly to these requirements than that of a continent or main land.

1340. The atmosphere should be serene, pure, soft, moist, and genial; the soil clay or marl; but if the disease be attended with *copious expectoration*, a mild and dry atmosphere and a calcareous soil are demanded. The southern or western shore of a continent, or of an island, exposed to the full influence of the solar rays, and screened or protected by hills and high lands from the asperity of the north and north-east blasts, from the mistral, sirocco, and keen north-west wind, and but little subject to gales of wind, is to be chosen.

1341. The localities which have been found most beneficial as a residence by the phthisical patient are Madeira, Malta, Palermo, the islands in the bay of Naples, and Pisa. As a temporary abode, Rome, Torquay, Undercliff, Clifton, Cove, Hastings, and the west cliff of Brighton.

1342. The south coast of England, Ireland, Guernsey, Jersey, the peninsula of Britany, and the western coasts of

Normandy, are celebrated for the mildness of their winters, the low temperature and overcast sky of their summers, and the humidity of their atmosphere, and are in consequence suitable for the temporary residence of the phthisical patient, the subject of a dry cough, and of an irritable condition of the lining membrane of the air-tubes. Most of these localities are, however, liable to occasional gales of wind.

1343. Change of climate is of little avail in the advanced stages of consumption. Indeed, it is an act of the grossest cruelty to expatriate the doomed phthisical patient, to tear him away from the family hearth, and separate him, on the verge of the grave, from the bosom of his family, and all its associations, without a shadow of a chance even of amelioration, much less of recovery. It is only in *incipient or threatening* cases that benefit can be anticipated from change of climate.

1344. Climate is therefore to be looked upon as a *preventive,* not as a *curative* means.

1345. As the diseases peculiar to the winter of each locality are, as a rule, cured by the summer, the pulmonic patient should reside abroad, at the least two winters and two summers.

1346. In every functional derangement, and in every organic affection, wheresoever seated, a frequent change of climate is useful.

1347. *Phthisis trachealis.*—In *phthisis trachealis,* and in a dry and irritable condition of the mucous membrane of the larynx and trachea, a warm, soft, humid atmosphere, a clayey, marly soil, a well-sunned southern or south-western aspect, and a low-lying locality, are clearly indicated. Madeira, Malta, Pau, Pisa, Rome, the west and south-west coasts of this island, Devonshire, Undercliff, west side of Brighton, and Cove, have been found pre-eminently useful in these affections.

1348. Patients who are suffering from a dry and irritable condition of the mucous membrane of the air-passages, and who are unfortunately unable to resort to a moist and warm climate, would find great relief from open vessels filled with

hot or even cold water, placed in their dwelling and sleeping apartments, in order to supply by evaporation any deficiency of moisture in the air. The temperature of the rooms should range from 63° to 66° Fah.

1349. *Bronchitis.*—In *chronic bronchitis,* and in a moist condition of the air-passages, a dry, tonic, bracing air, a chalky or gravelly soil, an elevated situation, and a bright sunny aspect, are required, such as are found at Nice, East Cliff Brighton, Malvern Hills, and Clifton.

1350. "*Clergyman's throat.*"—That follicular condition of the mucous membrane of the fauces and larynx to which clergymen as a class are peculiarly subject, and to which the name of "*clergyman's throat*" has been applied, is intimately associated with a deranged condition of the alimentary canal and chylopoietic viscera generally, and is not so directly or so immediately benefited by change of air, as by a restoration of the healthy state of the secretions generally, and of the mucous surfaces in particular, and by a strict adherence to a well-chosen and well-regulated diet. A dry tonic bracing air, chalky or gravelly soil, and an elevated locale will be found beneficial. Palermo, Nice, Clifton, or the East Cliff, Brighton, are indicated.

1351. *Struma.*—If there be one class of disease in which the salutary inflnence of climate stands out more prominently and more strikingly than another, it is in the strumous habit. In what form soever struma may shew itself, whether in that of ophthalmiæ, coryza, otorrhœa, tumid lip, glandular enlargements, dyspepsia, sluggish bowels, head-aches, tuberculous deposit, or in affections of the joints or bones, there is nothing to be compared to *marine atmosphere,* but more particularly to that of a dry and bracing sea-coast town such as Brighton. The atmosphere of soft, moist, relaxing localities, that especially of the west and south-west shores of our island, is, as a general rule, worse than useless in this disease, excepting always n its pulmonary developements, in which class of cases it is to be preferred to that of the dry, tonic, and bracing coast towns.

1352. As, however, the cure or eradication of this disease is one of *time*, of *years*, and not of weeks or of months, a permanent residence on the sea-shore is imperative. How often do we see, time after time, the child labouring under that which is conventionally termed "constitutional debility" taken to the sea-side, under a vain delusion that a fortnight, or at most a month or six weeks of sea-breeze will reinstate his health, and restore the lost bloom to his faded cheeks. This is at best but so much waste of health, to say nothing of money. The disease, week by week, month by month, takes a firmer and a deeper hold, and at last, when possibly too late to prevent disfigurement or mischief, that course is adopted which at the outset would, in all probability, have resulted in restoration to sound and vigorous health, but which now can, at the expiration of years even, end only in disappointment and regrets.

1353. Of the localities in this country which have become the resort of the invalid, or of the pulmonary patient, we may enumerate Hastings, Dover, Brighton, Worthing, Ventnor, Clifton, Torquay, Penzance, and Malvern, and Cove in Ireland; in France, Pau and Nice; and in Italy, Pisa, Rome, Naples, and the isles of Capri and Ischia; in Sicily, Palermo; and the islands of Malta and Madeira.

1354. With a few preliminary remarks on some of these places we shall conclude this division of Hygiene by a table, for the matter of which we are in a great measure indebted to Sir James Clark's work on climate before referred to, embracing the temperature, pressure, and humidity of the atmosphere of each locality, where recorded; the aspect and soil; the winds which prevail at different periods of the year; those disorders or diseases in the treatment of which each place has been found beneficial, and those in which it has been considered prejudicial.

1355. *Hastings* claims attention, on account of the shelter it affords from the cold searching northerly and easterly winds, which, so long as the patient remains in the valley of the town, which runs nearly north and south, blow over his head:

here, though he feels neither their bitterness nor their intensity, he yet misses the purifying influence of the southerly winds; let him, however, but venture on the tops of the east or west hill, and he will assuredly be driven back for shelter and protection to the town below.

1356. *The vale of Hastings,* then, from the configuration of the surrounding country, has a climate *proper to itself.*

1357. *Dover.* Similar conditions exist at, and the same remarks therefore apply to, Dover.

1358. *Brighton.* The eastern side of Brighton is situate on a high cliff, of which the soil is chalk. On the western side, which is a little above the sea-level, the soil is clay. The former is sheltered from the north by the Downs: the latter is open to the winds of this quarter, but is partially screened from the east by the mass of buildings on that side of the town.

1359. The surface drainage and sewerage are unexceptionable, but the sad mistake has been committed of carrying into the sea the whole of the sewage of the town by one outlet, near its centre, by which the purity of the waters for bathing purposes has been more or less sullied, and the atmosphere of that locality loaded with noxious emanations, which, by a southerly wind, are wafted over that portion of the town.

1360. Brighton, during the latter half of February, the whole of March, and first half of April, should be shunned by the pulmonary invalid, on account of the cold, dry, parching east and north-east winds which prevail during the winter quarter.

1361. The subjects of congestion of the liver, and of hepatic derangements, would do well to avoid Brighton.

1362. *Worthing.* The atmosphere of Worthing is softer, moister, and warmer than that of Brighton. The soil is clay and marl. Recent improvements in the drainage and sewerage of the town have made it more healthy than formerly.

1363. *Undercliff.* This is an example of soil and elevation

rendering an otherwise soft, warm, and moist situation, dry, tonic, and bracing.

1364. *Clifton.* The position of this town on the western confines of this island would have ensured for it a soft, warm, humid atmosphere, were it not that its soil, limestone rock, by absorbing all moisture, renders its atmosphere dry and somewhat bracing.

1365. *Torquay* and *Penzance* possess all the advantages of extreme warmth and moisture; and the latter place especially enjoys, day and night, an exceedingly equable temperature, in consequence of the vapours and mists from the Atlantic, with which the atmosphere is loaded during the prevailing south and south-westerly winds, precluding the sun's rays reaching the earth. (582.)

1366. The isle of *Capri,* in the Neapolitan Gulf, is one of the driest climates in the south of Europe. It consists of hard calcareous rock, covered here and there with a rich soil. Malaria is almost unknown on the island. The climate, which is warm during the spring, autumn, and winter, and hot during the summer, has been found particularly useful in rheumatism and in moist bronchial and phthisical affections. The longevity of the natives is perfectly fabulous.

1367. The isle of *Ischia,* in the bay of Naples, consists of calcareous rock, covered with a fertile soil. The climate, which is very similar to that of Capri, has been found useful in those affections which are relieved by a residence in the latter isle.

1368. Palermo (*Felice*) is situate on a fertile plain, surrounded by mountains, "the vale of the Golden Shell," at the head of a bay, five miles deep, on the northern coast of Sicily, screened on the north-west by the rock of Santa Rosalia and the Cape di Gallo, and on the east by Cape Zafferano.

1369. "In a clime which blends the oriental palm and aloe with the orange-tree, the fig, the olive, and the vine: cheered by the brightest sun, refreshed by the purest breeze, and

looking upon the dark blue wave, Palermo is one of the most attractive spots in the world." This more especially applies to winter, spring, and autumn. The summer is excessively hot, the thermometer, during the day, in June, July, and August, ranging from 80° to 90°, and, if the sirocco blow, reaching to 100°. Cold is unknown in Palermo. In the winter months the temperature rarely falls below 40°.

1370. The prevailing winds are west and south-west. Refreshing balmy gales from the north occur in winter.

1371. Rains of a tropical violence, which continue without intermission for three weeks, set in about the latter end of October or beginning of November, and are succeeded by the *second summer*, or summer of San Martino. This summer of St. Martin is not peculiar to Palermo, but is common to Italy, Switzerland, and the neighbouring countries.

1372. Those parts of the city which are built on the site of the ancient port are exposed to malaria during the autumn months.

1373. The atmosphere of Palermo is exceedingly dry, and the sky serene and transparent. The climate is steady and little exposed to gales of wind. In this particular it is infinitely superior to Malta, and is surpassed by no other place in Europe.

1374. Were its advantages of climate more generally known and more properly appreciated, Palermo would deservedly become the favoured resort of invalids, and would speedily cast into the shade many, if not the greater part, of those localities which are now frequented by the pulmonary and the dyspeptic.

1375. The climate of Palermo will be found useful in phthisis attended with copious expectoration, in chronic bronchitis, bronchitic asthma, atonic dyspepsia, in nervous and relaxed constitutions, in scrofula, and chronic rheumatism; and on the other hand, will be injurious in a dry, irritable condition of the air-passages and bronchi, and in inflammatory dyspepsia.

1369. Knight's Normans in Sicily.

		Annual mean temp.	Mean temperature of, and prevailing winds in					
			Jan.	Feb.	March.	April.	May.	June.
a	London . .	50·48°	38·52°	39·42°	42·51°	48·31°	55·01°	60·07°
b	Hastings .	50·73°	N.NE. and SW. winds.			S.W.	SW. and E.	
			37·63	38·16	41·89	47·40	53·76	61·55
c	Brighton, at 200 feet above the sea-level.	49·45°	Mild and dry.	Dry, piercing E. and NE. winds.		Showery.		
			40·15	39·65	42·00	46·46	51·53	57·50
d	Undercliff .	50·69°	Mild.				Sea-fogs.	
			41·83	41·81	44·50	48·68	54·61	59·08
e	Clifton . .	51·26°	Mild and dry. 39·91°			49·79°		
f	Torquay .	52·12°	44·05°			50·08°		
			37·07	41·02	47·43	50·13	54·94	59·08
g	Penzance .	51·80°	S. and SW. winds. Mild.			NE. winds.		
			42·50	43·50	46·40	48·50	54·00	58·50
h	Pau . . .	54·95°	Dry.	Rain.	Variable	Rain. W.winds	Soft mild rain.	
			38·89	44·96	46·80	55·79	62·31	62·31
i	Nice . . .	59·71°	Cold, dry, sharp N. winds.		Sharp chilling E. and NE. winds.			
			45·85	49·00	51·45	57·00	63·00	69·00
k	Pisa . . .	60·38°	44·00	48·11	51·52	56·30	63·75	70·50
l	Rome . .	60·67°	Dry, keen, irritating Tramontana, or N. winds. Frosts.					
			47·65	49·45	52·05	56·40	64·50	69·17
m	Naples . .	61·29°				Cold, sharp, irritating winds.		
			46·50	48·50	52·00	57·00	66·50	71·00
n	Malta . . (Valetta).	67·50°	NW. winds.	Boisterous tropical rains. Thunder-storms.			NW. winds.	
			56·50	56·50	58·50	63·00	69·00	74·00
o	Madeira . . (Funchal).	64·55°	N. winds, SE. and rain.	SW. moist.	NE. SE. SW. winds, showery.			
			59·50	58·50	61·00	62·50	63·00	65·00

	Mean temperature of, and prevailing winds in						Difference of mean temp. of warmest and coldest months.	Annual range of temp.
	July.	Aug.	Sept.	Oct.	Nov.	Dec.		
a	63·45°	64·41°	59·18°	51·33°	43·86°	39·76°	25·89°	72·9°
b	SW. and E.			E. and SW.				
	61·08	59·22	57·46	55·50	53·51	41·6	23·92	60·0
c			rains.	Mild and dry.				
	59·83	60·93	55·63	51·46	45·43	42·86	21·28	58·66
d	Mild.							
	59·49	62·28	57·30	52·58	48·40	42·80	20·47	55·0
e	63·87°			51·49°			23·00	. .
f	61·26°			53·11°				
	63·64					39·84	20·00	. .
g	61·20	60·90	57·60	53·70	48·80	46·10	18·70	45·0
h	Very hot, sometimes 94° in the shade.					Dry.		
	71·73	68·19	65·80	54·34	46·79	41·53	32·84	68·
i	Heat excessive.				Heavy rains.	rain.		
	73·50	74·30	69·35	61·85	53·70	48·60	28·45	60·0
k	77·50	77·50	73·50	62·62	52·30	47·00	33·50	. .
l	Heat excessive, especially with Sirocco, or S. wind.				Frequent and heavy rains.			
	73·30	74·02	69·50	63·60	58·80	49·62	26·37	62·0
m	75·00	76·50	72·50	65·00	54·50	50·50	30·00	64·0
n	SE. winds.	Heavy dews.		Dry NW. winds.				
	79·00	81·50	77·50	70·50	65·00	59·00	25·00	. .
o	NE. winds.			S. or SW. rain.	W. winds; fine.			
	70·00	73·00	71·50	67·50	62·70	60·50	14·50	35·0

		Mean daily range of temp.	Annual mean height of barometer in inches.	Annual range of barometer in inches.	Annual mean quantity of rain in inches.	Number of days on which rain falls.	Number of fine days.	Number of variable days.
a	London	11·37°	29·823	2·07	24·804	178		
b	Hastings	. .	29·72	. .	31·91	155·43	. .	. .
c	Brighton	. .	29·594	1·730	24·820	176	189	. .
d	Undercliff	9·58	. .	. .	26·230	146	. .	. .
e	Clifton	. .	29·733	. .	32·560	149	156	60
f	Torquay	11·00	. .	. .	28·20	132	. .	. .
g	Penzance	6·75	29·620	1·950	44·715	164	114	87
h	Pau	7·58	. .	. .	. .	109	155	101
i	Nice	8·58	. .	. .	20·782	. .	. .	. .
k	Pisa	. .	. .	.	45·66	. .	. .	. .
l	Rome	10·91	29·893	1·221	31·173	117	197	51
m	Naples	13·33	29·554	1·154	. .	97	210	58
n	Malta	6·00	. .	. .	15·00	. .	. .	. .
o	Madeira	10·33	30·030	1·211	25·026	73	201	91

	SOIL.	Situation.	Aspect.	Sheltered on	Exposed on
a					
b	Sand and sandstone rock.	Sea-level.	S.	N. N.E. E. W.	S. S.W.
c	Eastward of Steyne, chalk. Westward of Steyne, clay.	Sea-level.	S.S.W.	N.	N.E. E. S. S.W.
d	Chalk and sandstone.	From 40 to 70 feet above sea-level.	S.	N. N.E. W. N.W.	E. S.E. S.W.
e	Carboniferous limestone rock.	On southern acclivity of a hill.	S.	W.	S.E. S. S.W.
f	Limestone rock.	Sea-level.	S.W.	N.E. S.E. N.W.	
g	Limestone rock.	Sea-shore.	S.E.	. .	N.E.
h	Gravel.	On a ridge of hills.	N.	S.	N.
i	Rock.	Sea-level.	S.	N. E.S.E. to W.S.W. N.W.	S.
k	Alluvion.	On N. bank of Arno, four miles from sea.	S.	N. E. N.W.	
l	Volcanic rock.	On a plain or table-land 35 to 235 feet above sea-level.			
m	Volcanic rock.	On sea.	S.	N. N.E.	S.
n	Calcareous rock.	Valetta, on declivity of a hill.	N.E.	. .	. .
o	Basalt rock.	Sea-level.	S.	N.	S.

	Atmosphere.	Salutary in	Injurious in
b	Dry and still, except when southerly winds blow.	Chronic bronchitis, pulmonary consumption.	Irritable state of digestive organs, especially in nervous temperaments.
c	Dry, tonic, and bracing. East of Steyne, dry and sharp. West of Steyne, milder, somewhat damp.	*East Cliff.*—Bronchitis, hay fever, clergyman's throats, relaxed habits, constipation. *West Cliff.*—Phthisis, delicate and nervous temperaments.	Dry irritable state of mucous lining of air passages, inflammatory dyspepsia, tendency to hepatic congestions.
d	Equable, mild and dry, yet rather sharp and bracing.	Pulmonary diseases, hæmoptysis.	
e	Mild, dry, and elastic, but somewhat exciting.	Hæmoptysis, congested and relaxed mucous surfaces of air-passages and alimentary canal, inflammatory dyspepsia, relaxed habits.	Phthisis, irritable condition of bronchial membrane, atonic dyspepsia.
f	Soft, moist, and relaxing.	Chronic bronchitis, incipient phthisis, irritable mucous membrane of air-passages producing dry cough.	Relaxed mucous membrane of air passages, accompanied with copious secretion, hæmoptysis.
g	Warm, soft, soothing, and relaxing, subject to frequent and violent gales from S.W.	Dry and irritable mucous surface of air-passages, inflammatory dyspepsia, dysmenorrhœa.	Relaxed mucous lining of air-passages, attended with copious secretion.
h	Cold, calm, and rainy, rapid alternations of temperature.	Chronic aff. of larynx, trachea, bronchi, and mucous surfaces, inflammatory dyspepsia.	Bronchitis, phthisis, rheumatism, atonic dyspepsia.
i	Very dry, warm, exciting, and irritating.	Bronchitic asthma, chronic bronchitis and rheumatism, atonic dyspepsia, relaxed and torpid habits.	Phthisis, with dry and irritable mucous lining of air-passages, inflammatory dyspepsia, cerebral tendencies.
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l	Still, calm, mild, and soft, but rather relaxing and oppressive.	Dry, irritable bronchial membrane, tubercular phthisis, chronic rheumatism, inflammatory dyspepsia.	Phthisis, menorrhagia, apoplectic tendencies.
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n	Windy, dry, clear, mild, and bracing.	Bronchitic asthma, scrofula, and dyspepsia.	
o	Mild, equable, steady, and uniform.	Bronchitis, phthisis.	

a. Howard, op. cit.

b. "Hastings, a Resort for Invalids, by James Mackness, M.D." 2nd edit. London, 1850.

c. The results of three years' accurate observations with a registered K.O., and one of Zambra and Negretti's self-registering thermometers and standard barometers, the readings of the latter reduced to 32° Fah., kindly contributed by J. A. Hingeston, Esq. The height of the thermometer, and of the barometer, as rendered above, neither represents the temperature nor the pressure of the atmosphere proper to Brighton. A correction of 0·666° to the temperature (90), and of 0·218 inch to the pressure (48), must be added for the elevation above the sea-level at which Mr. Hingeston's observations are made. The annual mean temperature of Brighton will therefore be 50·11°, and the annual mean height of the barometer 29·812 inches.

d. g. et seq. Sir James Clark, op. cit.

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The Figures refer to the Paragraphs.

T

ERRATA ET CORRIGENDA.

Page 18, Note, 68, *dele* "Leslie, op. cit. p. 3."
,, 28, ,, *instead of* "117," *read* "116."
,, 53, ,, ,, "236," ,, "235."
,, 64, ,, ,, "309," ,, "310."
,, 102, paragraph 581, line 5, *for* "ye," *read* "you."
,, 196, ,, 1064, ,, 4, *instead of* "for," *read* "which permitted."
,, 264, ,, 1367, ,, 2, *for* "calcareous," *read* "volcanic."

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